Book_6

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POWERING PROGRESS

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Conductors

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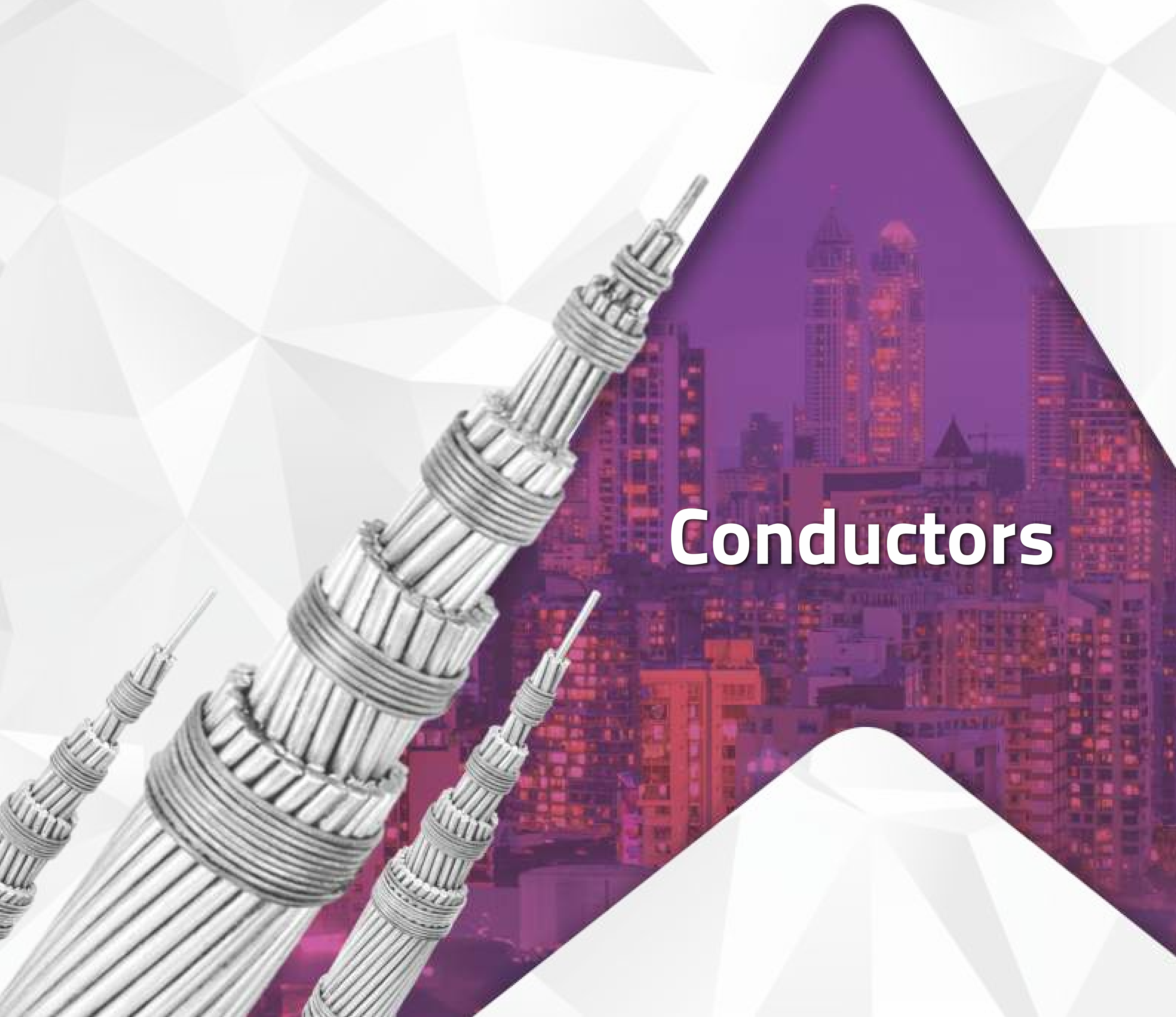

Conductors

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Conductors

DIAMOND POWER INFRASTRUCTURE LIMITED

Dear Fellow Power Engineers & Esteemed Customers

With our best regards to all our fellow power Engineers, Consultants and valued customers, we take this opportunity to put forward 'Revised-updated-conductor Manual" for your reference and parting further more technical updated details with inclusion of more technical parameters as regards to conductor field.

We have had overwhelming response for our earlier conductor – manual, by which we had put our best possible efforts to provide the technical assistance to all Government/Public sector corporates by providing all important technical parameters keeping in view Indian as well as International standards for achieving proper selection aspects as far as overhead conductor selection / usage is concerned.

The publication of this revised-updated conductor-manual, is dedicated to our esteemed customer consultants and all Government/ Private Sector /Public Sector, Corporates as a reference guide – which will help all those who are associated and involved in development of overhead transmission and distribution field.

Technical team

Cutting-edge technology; New-age facilities

Our infrastructural base comprises two state-of-the-art manufacturing plants. The facilities are spread over 260 Acres, which also include the Warehouse and the R&D centre of the Company.

Integrated Plant: Vadadala, Vadodara

The Company's present manufacturing facility was set up at village Vadadala, Ta. Savli, Dist. Vadodara, 400 kms. from India's commercial capital of Mumbai, in 1994 and expanded in 1999. The facility at present manufactures 100000 MT. of Rods, 250500 MT. of AAC, AAAC and ACSR Conductors and 55000 kms. of Power, Control and Aerial Bunch Cables. The key equipments are:

- Two oil fired furnaces with a capacity of 20 MT. each integrated with online solution heat treatment plant & Rod mill
- 10 very high speed fully Automatic Wire Drawing Machines
- 10 stranding machines of 1+6 strands and 12 of multi strands including 3 lines facility to make 61 and 91 stranding conductors for EHV applications in one process
- The Cables division is equipped with 3 extrusion machines, 2 laying machines & other allied machines
- Five DG sets of 625 KVA, Two DG sets of 500 KVA and Three DG sets of 1025 KVA for back-up purposes

Quality Policy

We firmly believe that quality leads to customer delight, which is why we have developed stringent quality measures and standards. DPIL implements a structured Quality Policy with well-defined objectives and goals.

Quality Objectives

- Maintaining consistency in product attributes, timely delivery, and services
- Encouraging participation of employees in improving quality and efficiency
- Safe and healthy work environments and optimized utilization of energy resources
- Continual employee training

Quality Certifications

Third party validation of products is a significant way of measuring quality in the market place. Our products have been type tested at:

a. Central Power Research Institute, Bangalore
b. Electrical Research and Development Association, Vadodara
c. TAG Corporation, Chennai
d. Govt. Testing Laboratory, Govt. of Haryana
e. Bureau of Indian Standards labs

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POWERING PROGRESS

CONVERSION FACTORS AND FORMULAE

CONVERSION FACTORS TABLE

These units	Multiplied by	Equal
Amperes per sq. cm	6.452	Amperes per sq. in
Ampere-turns	1.257	Gilbert
Ampere-turns per cm	2.540	Ampere-turns per in
British thermal units	778.3	Foot pounds
	3.930×10^{-4}	Horsepower hours
	1.055	Joules
	2.931×10^{-4}	Kilowatt hours
B.t.u. per min	12.97	Foot-pounds per sec
	0.02357	Horsepower
	0.01758	Kilowatts
	17.58	Watts
Centimeters	3.281×10^{-2}	Feet
	0.3937	Inches
	6.214×10^{-5}	Miles
	393.7	Miles
	1.094×10^{-2}	Yards
Centimeter-dynes	7.376×10^{-8}	Pound-feet
Centimeter-grams	7.233×105^{5}	Pound-feet
Centimeter per sec	1.969	Feet per minute
	0.03281	Feet per sec
	0.02237	Miles per hour
	3.728×10^{-4}	Miles per minute
Circular mils	7.854×10^{-7}	Sq. inches
	0.7854.	Sq. mils
Cms Per sec Per sec	0.03281	Feet per sec Per sec
Cubic Centimeters	3.531×10^{-5}	Cubic feet
	3.102×10^{-2}	Cubic inches
Cubic feet	7.481	Gallons U.S./6.228 imp. gal
	59.83	Pints (liquid) US
	29.92	Quarts (liquid) US
	49.83	Pints (imperial)
	24.915	Quarts (imperial)
Cubic meters	35.31	Cubic feet
	61.024×10^{3}	Cubic inches
	1.308	Cubic yards
	264.2	Gallons US
	2113	(1,759 imperial) pints (liquid)
	1057	(879 imperial) quarts (liquid)
Degrees (angle)	0.01745	Radians
Degrees per sec	0.1667	Revolutions per minute
Dynes	2.248×10^{-6}	Pounds
Ergs (dyne- CM)	9.480×10^{-11}	British thermal units
	7.378×10^{-8}	Foot pounds
	10^{-7}	Joules
Ergs per sec	5.688×10^{-9}	B.t. units per minute
	4.427×10^{-6}	Foot-pounds per minute
	7.378×10^{-8}	Foot-pounds per sec
	1.341×10^{-10}	Horsepower
	10^{-10}	Kilowatts
Feet of Water	62.43	Pounds per sq. foot
	0.4335	Pounds per sq. inch
Feet per minute	0.01667	Feet per seconds
	0.01136	Miles per hour
Feet per sec	0.5921	Knots
	0.6813	Miles per hour

These units	Multiplied by	Equal
Foot-pounds	1.285×10^{3}	British thermal units
	1.356×10^{7}	Ergs
	5.050×10^{-7}	horsepower hours
	1.356	joules
	3.766×10^{-7}	kilowatt hours
Foot-pounds per sec	7.709×10^{-2}	B.t. units per minute
	1.818×10^{-3}	Horse power
	1.356×10^{-3}	Kilowatts
Gallons U S	0.1337	Cubic feet
	231	Cubic inches
Gallons per minute	2.228×10^{-3}	Cubic feet per sec
Gausses	6.452	Lines per sq. inch
Gilbert	0.7958	Ampere-turns
Gilbert per CM	2.021	Ampere-turns per inch
Grams	980.7	Dynes
	15.43	Grains
	0.03527	Ounces
	0.03215	Ounces (troy)
	2.205×10^{-3}	Pounds
Horsepower	42.42	B.t. units per minute
	33,000	Foot-pounds per minute
	550	Foot-pounds per second
	1.014	Horsepower (metric)
	0.7457	Kilowatts
	745.7	Watts
Horsepower (boiler)	33.250	B.t.u. per hour. Kilowatts.
	9.804	Kilowatts.
Horsepower hours	2,545	B.t. units
	1.98×10^{6}	Foot-Pounds
	2.684×10^{6}	Joules.
Inches of water	0.5781	Ounce per sq. in.
	5.202	Pounds per sq. ft.
	0.03613	Pounds per sq. in.
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	0.03613	Pounds per sq. in.
Joules (Int.)	9.480×10^{-4}	B.t. Units
	10	Ergs
	0.7378	Foot-pounds.
	2.778×10^{-4}	
Kilograms	980.665×10^{-3}	Dynes.
	2.205	Pounds
	1.102×10^{-3}	Tons (short)
Kilogram per sq. mm.	14.223	Pounds per sq. inch.
	0.0063497	Tons per sq. inch.
Kilogram per sq. mm.	1,422.3	Pounds per sq. inch.
Kilometer	0.62137	Miles.
	1,093.61	Yds
	3,280.84	Ft.
Kilolines	10^{3}	Maxwells
Kilowatts	56.88	B.t. units per min
	4.427×10^{4}	Foot-pounds per min.
	737.8	Foot pounds per sec.
	1,341	Horsepower
	10^{3}	watts.

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	4.427×10^{4}	Foot-pounds per min.
	737.8	Foot pounds per sec.
	1,341	Horsepower
	10^{3}	Watts

These units	Multiplied by	Equal
Kilowatt-hours	3,413	B.t.u. units per min.
	2.656×10^{6}	Foot-pounds
	1,341	Horsepower hours
	3.6×10^{6}	Joules
Lumens per sq. ft.	1	Footcandles
Megalines	106	Maxwells
Megohms	10^{6}	Ohms
Metre	3.281	Feet

VARIOUS TYPES OF CONDUCTORS

TYPES

The most innovative and revolutionary new technical concept has now taken concrete shape in the form of 'Aluminium Alloy Conductor' in the 'Transmission and distribution field" – a most effective breakthrough for energy conservation through improved conductor design.

Aluminium Alloy Conductor is a Generic name. The group generally includes AAAC-HS, AAC-HC, ACAR, AACSR, ABC etc.

Aluminium Alloy Conductors have been in use for over the last four decades in most of the developing countries for overhead transmission lines, particularly for extra high voltage and high voltage transmission ranging from 66kV to 400kV voltage class transmission and in coastal areas. Even for distribution voltage class of 33kV and 11kV, AAAC conductors have been proving technically most successful and superior to AAC and ACSR conductors.

AAAC-HS

AAAC-HS comprises heat-treatable Aluminium Alloy wires like AA 6201 (IS designation 64401) with UTS higher than 30 kg/mm², elongation more than 4% and conducting higher than 52.5%.

AAAC-HC

AAAC-HC comprises that treatable or age-hardened Alloy wires like AA6201 (IS designation 64401) or non-heat-treatable Alloy wires like AA 5005 (IS designation 51000 A), Ductalex EEE, etc., with UTS ranging between 20-25 kg/mm², elongation between 2% to 4% and conductivity ranging between 56% to 59%.

ACAR: (Aluminium Conductor Alloy Reinforced)

ACAR comprises EC grade Aluminium wires and high-strength Aluminium Alloy wires with adequate mechanical strength and overall electrical conductivity between 56% to 60%.

AACSR: (Aluminium Alloy Conductor Steel Reinforced)

AACSR comprises high-strength Aluminium Alloy wires reinforced with a high-tensile galvanized steel core with very high mechanical strength and adequate electrical conductivity.

ABC: (Aerial Bundled Cables)

ABC comprises compacted, bare/insulated high-strength Aluminium Alloy conductor as a neutral messenger wire bunched with three to five insulated EC grade Aluminium phase conductors and lighting conductors.

The typical data sheets covering the basic properties of the above types are put up here with Annexure 'A'.

For the above data sheets, it can be said that Tensile strength of drawn Aluminium Alloy wire is about two times more than that of EC aluminium wires. It is therefore the Alloy conductors, which are free from steel core, are about 25% lighter than ACSR conductors of equivalent strength.

Because of the low strength-weight ratio of new conductors for a specific value of sag, it is possible to increase the length of span, resulting in reduction in number of towers and hardware.

The electrical conductivity of the Alloy conductor is about 10% higher than the equivalent ACSR conductor. Moreover, because of elimination of steel core wires, there is no magnetic and eddy current effect resulting in low line loss.

Alloy Rod has high ductility, which enables it to draw in fine size wires.

Alloy conductors have high resistance to corrosion, which imparts much more life as compared to ACSR and are particularly useful in severe marine, industrial, and tropical environments.

Alloy strands have surface hardness twice that of EC grade Aluminium strands, thereby having high abrasion resistance and better surface finish resulting in low corona loss, less radio interference (RIV), and better performance under tension and compression.

Alloy strands have high creep resistance, high fatigue resistance, and superior structural stability even at varying temperatures.

For the production of conductor alloy, even high silicon content Aluminium with controlled impurities, which is largely available in India, may be used.

Alloy suitable for Aluminium conductors belongs to the AL-MG-Si system with varied composition. The most commonly adopted alloy in the country, designated as 6201, has the following nominal percentage of composition as per IS 9997 / 1991 (First Revision), with other technical parameters given in Annexure 'B' for mechanical and electrical properties.

VARIOUS TYPES OF CONDUCTORS

ACSR CONDUCTORS

The Aluminium conductors galvanized steel reinforced, briefly called as ACSR, comprise seven or more Aluminium and galvanized steel wires, built up in concentric layers. The Centre wire or wires are of galvanized steel, and the outer layer or layers are of Aluminium. As such steel core + Aluminium conductors have been widely adopted for high voltage transmission lines, especially for long spans. It has high tensile strength, but it reduces with the rise of temperature above 65°C.

There are many types of such composite conductors which are covered in IS 398 (P II) / 1976-1996, BS 0215 (P II) / 1970, and other international standards.

The conductivity of steel-cored Aluminium conductor is taken as that of the Aluminium portion alone, as the steel wires have high resistance to alternating currents.

The strength is taken as 85 percent of the sum of steel wires plus 95% of the sum of the strength of the Aluminium wires. The factor 85% and 95% allows for the stranding. The strength of Aluminium wires varies from 23,000 lb. per sq. inch (for larger wires) to 28,000 lb. per sq. inch (for small wires) and of steel from 179,000 lb./in² to 200,000 lb./in². The total strength of the steel-cored Aluminium conductor is normally 50% greater than that of equivalent copper conductors. And the weight is only three-quarters as much (one half due to Aluminium and a quarter to steel). It is claimed that the result is a conductor with smaller ratio of loading to strength than any other conductor, even allowing for increased wind and ice loads due to the increased diameter as compared with that of the equivalent copper conductor. The sag is therefore the least, so that supporting towers may be shorter or the span length greater for a given sag than for any other conductor. The larger diameter is useful in very high voltage lines as the corona losses are less.

ANNEXURE 'A'

AAAC - HS BASIC PROPERTIES

ULTIMATE TENSILE STRENGTH (kg/mm²)	
Minimum Average:	**30.00**
Typical	
Wire Diameter Range (mm)	
From 1.19 up to 3.30:	32.7
Above 3.30 up to 3.80:	32.0
Above 3.80 up to 4.30:	31.3
ULTIMATE ELONGATION (percent in 200 mm)	
Minimum:	4.0
Typical:	5.5
MODULI OF ELASTICITY (kg/mm²)	
Initial modulus (average):	5200 to 5600
Final modulus (average):	6250 to 6450
TEMPERATURE COEFFICIENT OF RESISTANCE per °C at (20° C)	0.00360
TEMPERATURE COEFFICIENT OF LINEAR EXPANSION per °C (Between 10 and 100°C)	23×10^{-6}
CREEP (10 year typical)	0.05%
BRINELL HARDNESS (BHN)	80
ELECTRICAL VOL. RESISTIVITY at 20° C (Ω·mm² / m)	
Standard:	0.0325
Typical:	0.0320
SPECIFIC WEIGHT (gram / cubic centimeters)	2.70
ELECTRICAL CONDUCTIVITY at 20° C (% IACS)	
Standard:	52.5
Typical:	53.3

AAAC - HS TECHNICAL ADVANTAGES

(Over Electro-Mechanically Equivalent ACSR)

MECHANICAL STRENGTH TO WEIGHT ratio is sufficiently high to avoid steel core, hence:

- **Light conductors:**
  - Smaller tension, smaller loads on angle and dead-end towers
  - Easier handling and transportation on site
- **Homogeneous conductors:**
  - Even distribution of stresses across the section
  - Smaller gyration, easier running out under tension
  - Simpler, safer, and economical joints
  - Higher value of scrap
- **SURFACE HARDNESS Twice that of Aluminium strands, hence:**
  - Less prone to damage and scratches during running out
  - Smaller corona losses and radio interference
  - Better performance under splicing and compression
  - Greater reliability in service, easier erection
- **CHEMICAL RESISTANCE**
  - In AAAC, absence of steel/zinc/Aluminium cell hence:
  - Better corrosion resistance in sea coast or industrial areas
- **ELONGATION Almost equal to that of steel - 4%**
  - In ACSR, for lines in mountains and estuaries:
  - Excellent mechanical homogeneity
  - High breaking strength for long spans

MANUFACTURING PROCESS OF AAAC & ACSR

ALL ALUMINIUM ALLOY CONDUCTOR (AAAC)

Manufacturing process involves special Thermo-mechanical treatment to obtain the desired properties of conductor. There are two methods generally adopted (1) Almelec process of France and (2) Aldrey process of Germany. In Almelec process of Alloy rod (9.5mm) is drawn to the intermediate size (6.7mm diameter and thereafter it is solution treated. The wire is then redrawn to the required size which is finally aged and stranded. Whereas in Aldrey process, the alloy rod is initially solution treated and thereafter directly drawn to required size and finally aged to obtain the desired properties.

SOLUTION TREATMENT

Solution treatment is the process by which super-saturated solid solution of Alloy structure is produced to take advantages of its precipitation hardening characteristics.

Alloy rod (9.5mm diameter) in coil is drawn to 6 mm intermediate wire drawing and charged in a large electrically heat and air circulated solution treatment furnace at a temperature of 535 degree centigrade (± 5%) with boiling time of 45 to 60 minutes thereafter immediately (within 30 sec) quenched in water (at room temperature). The coil is then rinsed to dry the surface of the rod completely.

The solutionised rod has to be drawn within 24-72 hours after solution treatment otherwise the rod will become harder due to natural aging and there will be difficulty in drawing operation.

DRAWING

Aluminium Alloy rod can well be drawn in slip type wire drawing machine having hardened and ground capstans with 450mm minimum diameter arranged in line. Capstans, dyes and wires are submerged in lubricant. In addition, fresh, cool lubricant is sprayed under pressure into the dye approach thus additionally increasing the coming lubricating and cleaning effect. The winding unit should have provision for cooling and separately driven by Torque motor or Eddy Current drive having taper tension characteristics.

While tapered drafting is adopted for copper, constant drafting procedure is adopted for EC grade Aluminium (constant 25% elongation per dye) and Alloys (constant 20% elongation per dye).

AGING TREATMENT

Artificial aging is the heat treatment to stabilize the structure of Alloy wire at desired hardness.

This drawn wire accommodated in the perforated bobbins and coil is changed in electrically heated furnace at a period of 4-5 hours at temperature of 150 to 165 degree centigrade for further aging of the wire.

The correct aging time and temperature will have to be established by actual practice to achieve the desired properties of the strands.

STRANDING

Stranding of finally drawn and aged wire are ideally done on floating type stranding but conventional rigid type tandem wire stranding machines having provision for the post forming arrangement, with special measures such as proper tensioning and the largest possible radius of curvature and for conductors, are normally used for high productivity.

TESTING

TYPE TESTS:

The following test shall be conducted once on a sample / samples of conductor to every 750 kms of production from each manufacturing facility:

a. UTS Test On Stranded Conductor
b. Corona Extinction Voltage Test (Dry)
c. DC Resistance Test On Stranded Conductor

ACCEPTANCE TESTS:

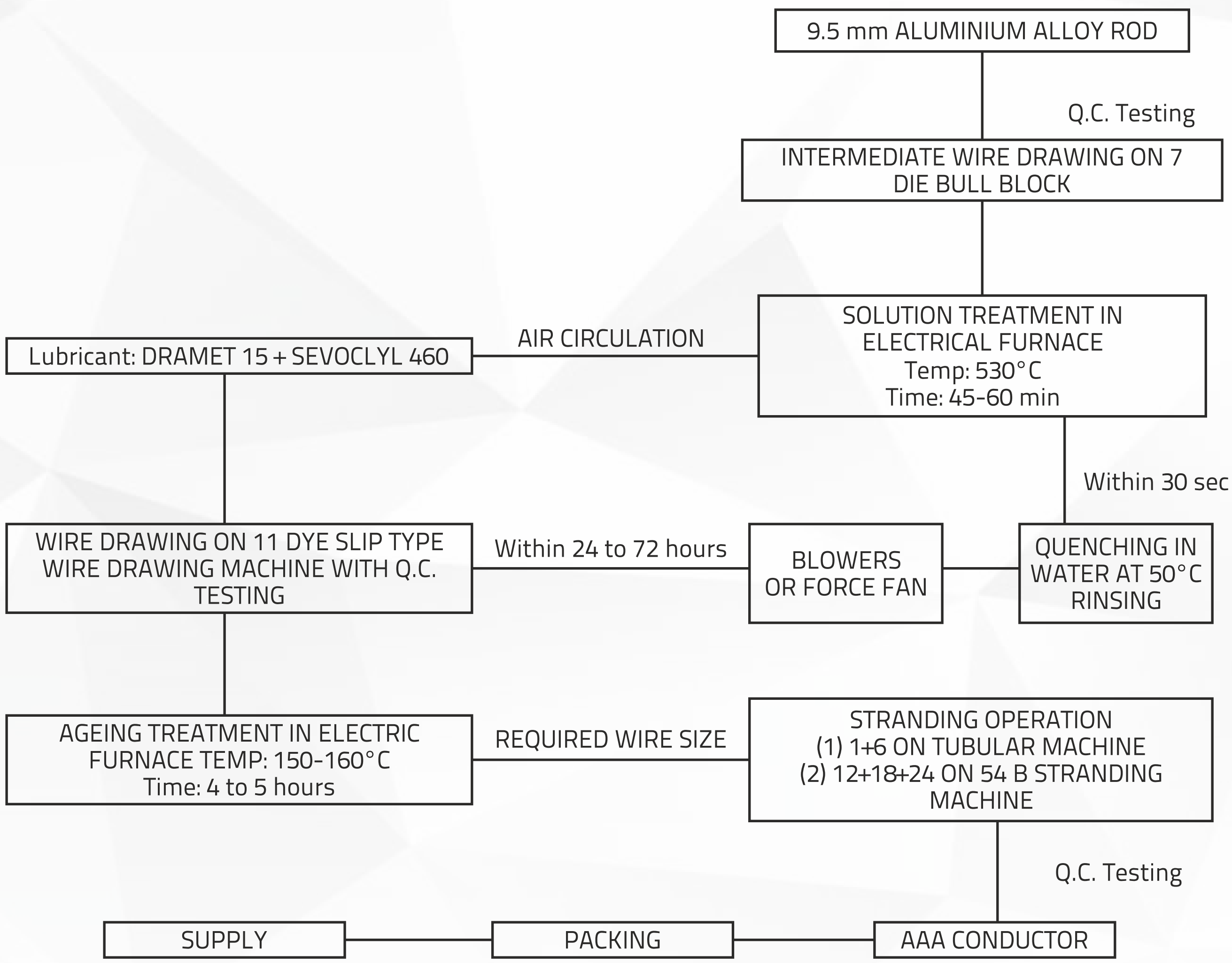
a. Visual and dimensional check on drum
b. Visual check for joints scratches etc. and lengths of conductors by rewinding
c. Dimensional check on steel and Aluminium strands
d. Check for lay ratios of various layers
e. Breaking load test on Aluminium strands
f. Wrap test on Aluminium strands
g. DC resistance test on Aluminium strands
h. Procedure qualification test on welded joint of Aluminium strands

Note: All the above tests except (h) shall be carried out on Aluminium Alloy Strands after stranding only.

ROUTINE TESTS:

a. Check to ensure that the joints are as per specifications
b. Check that there are no cuts, fins, etc. on the strands
c. Check that drums are as per specifications
d. All acceptance tests as mentioned above, to be carried out on each coil

PROCESS FLOW CHART-AAA CONDUCTOR



QUALITY ASSURANCE PLAN

Sr. No	Components & Operation	Characteristics	Type of Check	Reference Documents	Quantum of Check	Acceptance Norms	Format of Record	Agency
A	**Raw Material Testing** All Aluminium Alloy	(a) Dimension (diameter) (b) Tensile Strength (c) % of Elongation (d) Resistance/ Resistivity conductivity	Mechanical Measurement Mechanical Electrical	IS - 9997 - 1991	100%	As given in IS - 9997- 1991	Raw material analysis register and test certificate	Inspection and quality control department
B	**In Process Testing** Testing of Rod: Before Solution Treatment	(a) Dimension (diameter) (b) Tensile Strength (c) % of (d) Resistance Elongation Resistivity conductivity	Measurement Electrical Mechanical Mechanical	Standard process documents	100%		Process Inspection Register	Internal testing by OA Inspector
C	Testing of Rod: After Solution Treatment	(a) Dimension (diameter) (b) Tensile Strength (c) % of Elongation (d) Resistance Resistivity conductivity	Measurement Mechanical Mechanical Electrical		100%	Register	Process Inspection	
D	Testing of Rod : Before Ageing Test (lot)	(a) Dimension (diameter) (b) Tensile : Strength (c) % of Elongation (d) Resistance	Measurement Mechanical Mechanical Electrical	IS - 398 Part - IV 1994	100%			QA Inspection
E	Testing of Rod : After Aging Test (lot)	(a) Dimension : (diameter) (b) Tensile : Strength (c) % of Elongation (d) Resistance (e) Surface finish	Measurement Mechanical Mechanical Electrical Visual	IS - 398 Part - IV 1994	100%	IS - 9997- 1991		QA Inspection
F	Stranding	(1) Diameter (2) Direction (3) Lay Ratio : (4) Surface finish	Measurement Visual Measurement Visual	IS - 398 Part - IV 1994	Each Length Every Drum	As given in IS - 398 Part - IV 1994	Lay Ratio Chart	QA Inspection
G	**Finish Conductor Testing**	Measurement (a) Lay Ratio (b) Diameter (c) Breaking Load (d) % of Elongation (e) Resistance	Measurement Measurement Measurement Measurement Measurement Electrical	IS - 398 Part - IV 1994	100%	1994 As given in IS - 398 Part IV	Type Test Report & Test Certificate	Inspection & QC department counter checked by third party & BIS

ALUMINIUM CONDUCTOR STEEL REINFORCED (ACSR)

WIRE DRAWING OPERATION:

9.5 mm Diameter EC Grade Aluminum Rod is tested for surface finish, Diameter, Elongation, Resistivity Test etc., 'Quality OK' material will be taken for production. EC grade Aluminum rod is drawn into the required Diameter on Wet Type Wire Drawing Machine and it undergoes test like Elongation, Breaking Load, Resistance, Diameter Surface Finish, Wrapping Test etc.

SPOOLING OPERATION:

HTGS wires are tested for Diameter, Surface Finish Elongation, Breaking Load, Dip Test, Torsion etc., as per relevant IS standard. 'Quality OK' material undergoes to spooling operation.

STRANDING OPERATION:

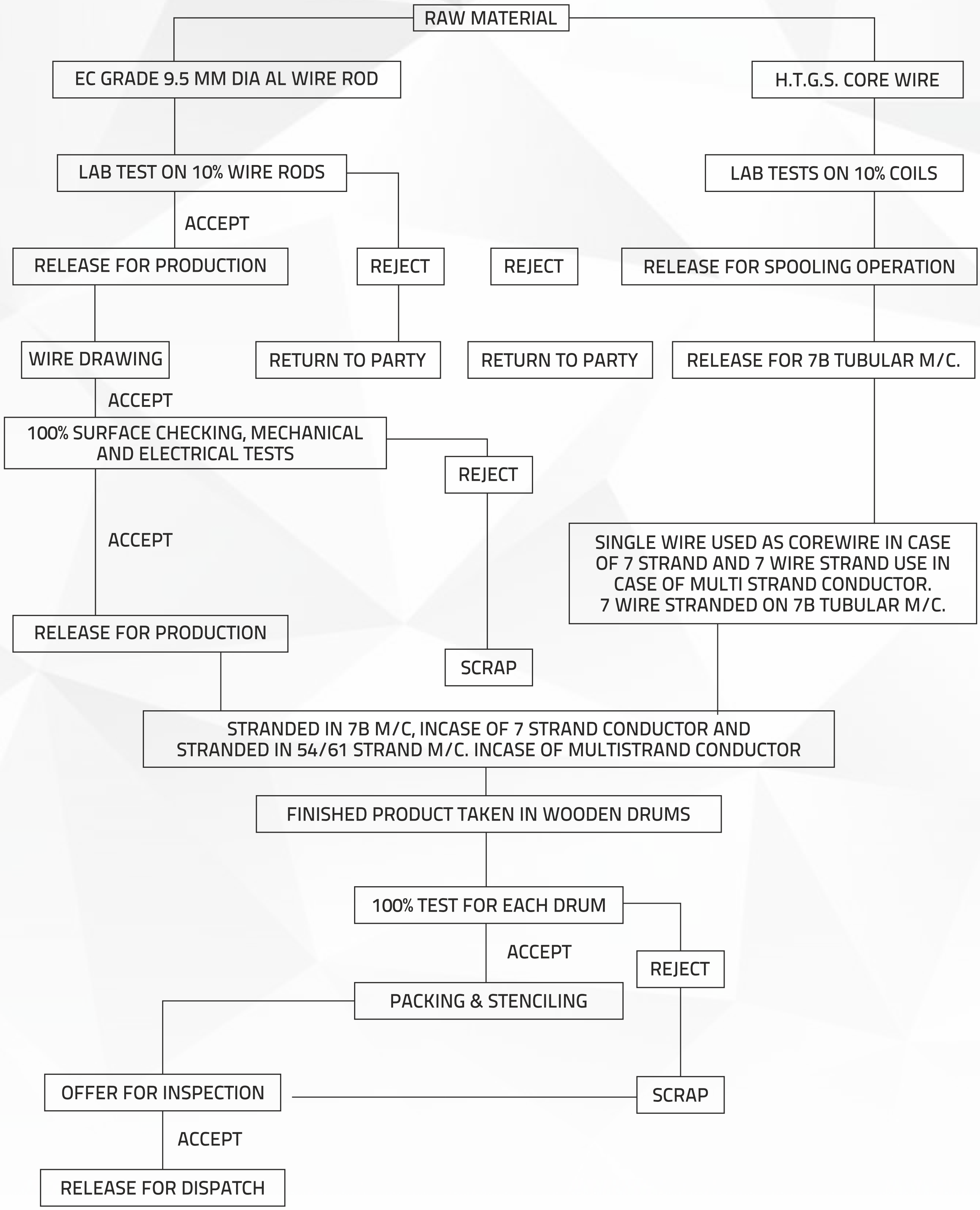
In case of small conductors i.e. conductors not having more than seven strands, center wire to HTGS wire will be stranded with six wires of Aluminum on Tubular Machine.

In case of multi layer conductor, seven HTGS wire are stranded on Tubular Machine and the same stranded conductor is again stranded with Aluminum wires on Multi Strand Machine in a required Wooden Drum. Packing and stenciling will be done as per IS 398 Part-II, 1996.

QUALITY ASSURANCE PLAN FOR ACSR CONDUCTORS

Sr. No	Components & Operation	Characteristics	Type of Check	Reference Documents Check	Quantum of Check	Acceptance Norms	Format of Record	Agency
1	Aluminium Rods	(a) Diameter (b) Tensile Strength (c) Conductivity	Measurement Physical Electrical	IS - 398 Part - II	100%	As given in IS-398 Part - II 1996	Raw material Analysis Registration	Inspection & QC department
2	Wire Drawing	(a) Diameter	Measurement Physical Electrical	IS - 398 Part - II	100%	As given in IS-398 Part - II 1996	Process Control Forms	Inspection & QC department
3	Stranding	(a) Lay Ratio (b) Surface Check (c) Resistance	Measurement Visual Electrical	IS - 398 Part - II	100%	As given in IS-398 Part - II 1996	Process Control Forms	QC Inspection & roduction Supervisor
4	Galvanized Steel Wires	(a) Diameter (b) Mass of Zinc coating (c) Dip Test (d) Torsion Test (e) Elongation Test (f) Wrapping Test (g) Lay Ratio	Measurement Chemical Chemical Physical Physical Physical measurement	IS : 4826 IS : 4826 IS : 398 Part - II IS : 398 Part - II IS : 398 Part - II IS : 398 Part - II	10%	As given in IS-398 Part - II 1996	Process Control Forms & Raw material Analysis Register	Inspection & QC department
5	Finished Conductor	Test on Aluminium (a) Diameter (b) Breaking Load (c) Lay Ratio : (d) Resistance	Measurement Physical Measurement Electrical	IS : 398 Part - II IS : 398 Part - II IS : 398 Part - II IS : 398 Part - II	100%	As given in IS-398 Part - II 1996	ISI Records and Test Certificate	Inspection , QC department & Customer Representative
6	Finished Conductor	Test on GI Wire (a) Diameter (b) Breaking Load (c) Lay Ratio (d) Mass of Zinc coating (e) Dip Test (f) Elongation (g) Wrapping	Measurement Physical Measurement Chemical Chemical Physical Physical	IS : 398 Part - II IS : 398 Part - II IS : 398 Part - II IS : 4826 IS : 398 Part - II IS : 4826 IS : 398 Part - II IS : 398 Part - II	100%	As given in IS : 4826 As giben in IS : 398 P - II 1996 As given in IS : 398 P - II 1996	Supplier's certificates are kept in record and randomly checked in QC department & register is maintained	Inspection , QC department & Customer Representative. Counter checked by BIS representative

PROCESS FLOW CHART - ACSR CONDUCTOR



COMPARISON OF AAAC & ACSR

WIRE DRAWING	OPERATION:
Aluminium alloy conductor is revolutionary break-through in conductor technology.Users all over the world are switching over to AAAC due to its technical superiority.	Aluminium conductor steel reinforced is outdated in technology. Its use is obsolete in developed countries due to technical and economical shortcomings.
Heat-treated Al-Mg-Si alloy makes AAAC totally free from bimetallic corrosion and exceptionally resistant to environmental corrosion.	In ACSR. corrosion (bi-metallic and environmental) because of steel core sets in within 2 years, lowering efficiency.
Service life is around 60 years-twice as durable as ACSR.	Service life ranges between 15-30 years. Particularly less in industrial and sea line atmospheres.
Hard to cut and impossible to recycle into utensils. Excellent inhibitor of theft, eliminating unwanted power breakdowns.	Easily cut and recycled overnight for making utensils. Stolen ACSR till date adds up to Rs. 100 crores even by conservative estimates.
AAAC has higher strength to weight ratio ranging between 10.6: 11.6 on an equal diameter basis. Offers savings due to reduction in number of towers, foundations and accessories.	ACSR has lower strength to weight ratio ranging between 88.4:9.4; hence requires lesser spans than AAAC. Lower cost of ACSR is offset due to higher cost of towers etc.
Suffers no reduction in strength on temperature rise upto 90°C since it is specially heat treated at 160t temp. Can be loaded to higher level of capacity.	Strength of ACSR reduces with rise in temperature above 65'C. Not suitable for overloading.
No steel core means, no magnetic losses. Thus zero additional line losses due to electromagnetic effect.	Steel core induces eddy current and hysteresis losses.
Repair and replacing, dead ending is easier because AAAC is monometallic. Ordinary fitting and accessories without steel inserts can be used. Works out to be economical in the long run.	Repairs are time consuming and frequent, requiring special procedures. Maintenance costs and inherent defects make it costlier in the long run.

Many other Advantages are also claimed for AAAC as listed below:

Lesser stretch AAAC stretches much less than AAC (All Aluminium Conductor) and less than ACSR under normal operating tension.

Higher Ampacity AAC when compared to ACSR size, possess about 10% higher conductivity. In other words, for equal temperature rise, AAAC can carry 10% extra current on the line.

Higher creep resistance AAAC stranded overhead conductors when subjected to static tensile stresses for a long period of time, have relatively smaller increase in sag.

1. **Characteristics of All Aluminium Alloy Conductor**
   1. AAAC alloy 6201 is claimed to have better corrosion resistance and better strength to weight ratio and improved electrical conductivity than ACSR on an equal diameter basis. This makes the AAAC better suited in corrosive areas like sea coast and industrial areas where high metallic corrosion sets in. The higher strength to weight ratio facilitates lesser sags on larger spans.
2. **Advantages of AAAC**
   1. Compatible thermal stability: MAC can perform at 90°C continuously for a period of one year literally with no loss of strength and it can operate safely at 150°C for 3 hours. Under short circuit conditions, temperatures upto 200°C for 0.5 Seconds can be easily withstood.
   2. Ease of repair: AAAC being monometallic in construction lends itself to easy repairs, splicing and dead-ending. It is claimed that there is a saving of about 50% time. Reduction of cost of work at site is about 20 to 25%
   3. Corrosion Resistance: Almelec AAAC exhibits excellent corrosion resistance in corrosive atmospheres like industrial areas.

COMPARISON OF AAAC & ACSR

However, laboratory tests at CPRI indicate that all Aluminium alloy materials are prone to marine corrosion in chloride atmospheres (pitting corrosion). Resistance to this marine corrosion has been investigated at CPRI and it has been found that a coating of zinc on the individual strands of the conductor will improve the life of the conductor as a whole. The zinc coating does not effect other properties of materials.

Of course there is no possibility of galvanic corrosion since the material is not bimetallic.

3. Power Saving Capability of AAAC:

1. The power saving by use of AAAC was quantified by CPRI. The details are enumerated in the ensuing paragraphs.
2. The saving in power results from lower resistance of MAC compared to that of ACSR conductor for equal conductor diameter. The resistances pertaining to MAC conductors are those furnished by the manufacturers. For ACSR conductors the resistance have been computed using the standard hand book (Wasting Hose Fourth U.S. Edition Oxford and IBH Publishing Corporation) and suitably extrapolating to match the size to conductor used in our country. Table 2 shows the resistance value of a few commonly used ACSR conductors and their AAAC equivalents.
3. Further, the percentage reduction in losses by use of MAC as substitute for ACSR conductor has been computed in two ways.
   i. Considering a hypothetical 100km line loaded to its full capacity i.e. 92)60 22A. & 180A for Weasel. Rabbit and Dog ACSR conductors and their AAAC equivalent respectively.
   ii. Taking a practical system with typical loading and applying ACSR and its equivalents MAC conductors, for calculating energy loss, loss load factor was used (LLF+) 0.2 x LF +0.8 x LF2). A diversity factor of 1.5 was assumed for the loads. The practical feeder, considered is enclosed at Annexure-II. system details are at Annexure-III.
4. The findings pertaining to the hypothetical system is given in Table 3. Calculations are given in Appendix-I.
5. Similar results for practical system are show in Table 4, The load factor was varied from 0.4 to 1.0 to study the dependence of economy on load factors. The details of calculations are appended in Appendix- IV.
6. Observations: it can be seen from Table 3 that the savings in peak load power loss by use of AAAC equivalent conductors varies between 12% and 14.5% depending on the type of conductor considered.

   In a practical system percentage saving in peak load power loss was found to be about 16.3 % (See Table 4) Under these conditions, the savings in annual capitalised cost due to lower energy loss with AAAC is found to vary from 2.5% at a load factor of 0.4 to 11.2% at a load factor 1. The other advantages claimed for AAAC can be verified only after obtaining the feed back from the field after long time use.

4. Conclusion

1. MAC is superior to ACSR conductors when used in overhead distribution system,
2. The increased cost of MAC (claimed to be 15% to 20% costlier than corresponding ACSR conductors) is offset by the saving in power loss.
3. Other advantages of AAAC are better thermal stability, ease of repair corrosion resistance, longer service life. less prone to pilferage as known through literature.

TABLE - 1 TYPES OF ALUMINIUM ALLOY CONDUCTORS

Alloy	Country	Standard
6201	U.S.A.	ASTM-B-398/ASTM-B-399
ALMELEC (AGS)	France	NEC-34125
SILMALEC (E91E)	U.K.	BS-1470-1477
ALDREY	Germany	DIN 48200/DIN 48201
ALDREY	Switzerland	ASE 021
ALMELEC	Italy	UNI 3570
IGO	Japan	JEC 74
ALMELEC (AAAC) -1979	India	IS: (PART-IV) 1979 IS 398 (P-IV) 1998

TABLE - 2 RESISTANCE OF ACSR AND AAAC EQUIVALENT CONDUCTORS

Conductor		AC resistance @ 50 Hz, 50°C per km in Ω
Type	Code Name	
ACSR	Weasel	1.093
AAAC	Equiv.	0.9620
ACSR	Rabbit	0.6792
AAAC	Equiv.	0.5751
ACSR	Dog	0.3600
AAAC	Equiv.	0.3080

TABLE - 3 SAVINGS AS PERTAINING TO THE HYPOTHETICAL SYSTEM

Type of conductor and code name		Peak load current	Peak load power loss	Energy loss annum per annum	Savings in energy loss	Savings
Type	Code Name	A	kW	Rs. Lakhs	Rs. Lakhs	%
ACSR	Weasel	92	2775	65.63		
AAAC	Equiv.	92	2443	57.78	7.85	12
ACSR	Rabbit	122	3033	71.74		
AAAC	Equiv.	122	2567	60.71	11.03	15.4
ACSR	Dog	180	3499	82.76		
AAAC	Equiv.	180	2994	70.81	11.95	14.44
LF=0.6, Rate per kwh = Rs. 0.45						

TABLE - 4 ECONOMICS FOR THE PRACTICAL SYSTEM CONSIDERED

Rate per kWh Re. 1/-

Sr. No.	Description	Type of conductor	Load factor						
			0.4	0.5	0.6	0.7	0.8	0.9	1.0
1.	Peak load losses (kW)	ACSR	72.57						
			60.72						
		AAAC Equiv. kW.	11.85						
2.	Savings in peak load losses	%	16.3						
3.	Annual capitalized cost (Rs.)	ACSR AAAC Equiv.	296357 288960	354843 337895	423500 395341	502328 461298	591328 535765	690500 612742	799842 710230
4.	Savings in annual capitalized cost	Rs. %	7397 2.5	16948 4.8	28159 6.45	41030 8.17	55563 9.4	81758 11.54	89612 11.2

COMPARISON FOR DOG CONDUCTOR

a) **AC resistance of ACSR Dog Conductors:**
Dog ACSR Conductor size 4.72 x 6.7 x 1.57 = 0.1858" x 6.7 x 0.80618"
As per Hand Book
AC resistance of 6 x 0.1878" stranded ACSR conductor at 50 Hz and 50° C = C = 0.567 fl / mile.
AC resistance of Dog
Conductor (Extrapolated)
= 0.567 x (0.1878') / (0.1852) = 0.579 Il per mile
= 0.36 SI / km

b) **AC resistance of equivalent AAAC - 0.3080 52 / km**

c) **Economy**

	ACSR Dog	AAAC equivalent
Peak load current (A)	180	180
AC resistance (Ω/km)	0.36	0.3080
Peak load losses for 100 km length (312 R) (kW)	3499	2994
Energy losses per annum @ 0.6 LF and Rs. 0.45 / kwh (in lakhs)	82.76	70.81
Saving in energy		11.95
losses / annum (Rs. Lakhs)		(14.44%)

CONDUCTOR - ELECTRICAL CHARACTERISTICS AND COST DETAILS:

Conductor Code	Type	Resistance per km (Ω)	Reactance per km (Ω)	Cost per km (Rs.)
Rabbit	ACSR	0.6792	0.372	41338
	AAAC	0.5751	0.372	47538
Weasel	ACSR	1.093	0.382	29151
	AAAC	0.962	0.382	33523

COMPARISON OF AAAC VS ACSR

Conductor Temperature	Wind Pressure	61/3.19 AAAC		54 + 7/3.18 ACSR	
		Tension	Sag	Tension	Sag
(°C)	(Kgf/sq.m)	(Kgf)	(m)	(Kgf)	(m)
32	0	3288	6.26	3322	7.47
53	0	2819	7.31	2972	8.35
75	0	2455	8.39	2686	9.24
90	0	2262	9.11	N.A.	N.A.
32	30	4613	4.46	4362	5.69
32	45	3990	5.16	3953	6.28

CONCLUSIONS

For all operating conditions, Sags and Tensions for AAAC are less than for equivalent ACSR. Also AAAC could be operated with higher Ampacity upto 90°C without affecting ground clearance as obtained for ACSR for75°C conductor temperature.

AAAC VERSUS ACSR ELECTRICAL COMPARISON

All Aluminium Alloy Conductor (6201)

CODE NAME	AREA KCMIL	REACTANCE		REACTANCE	
		CAPACITIVE	INDUCTIVE	AC 50°C	DC 20°C
Butte	312.8	0.1074	0.473	0.376	0.0644
Canlon	394.5	0.1040	0.459	0.298	0.0311
Cairo	465.4	0.1015	0.449	0.253	0.0133
Darlen	559.5	0.0987	0.438	0.214	0.0300
Elgin	662.4	0.0068	0.429	0.182	0.0309
Flint	740.8	0.0945	0.419	0.160	0.0272
Creele	927.2	0.0913	0.406	0.129	0.0217

Aluminium Conductor Steel Reinforced

REACTANCE		REACTANCE		AREA KCMIL	CODE NAME
DC 20°C	AC 50°C	INDUCTIVE	CAPACITIVE		
0.0640	0.3792	0.485	0.1074	268.8	Partridge
0.0507	0.3006	0.451	0.1040	338.4	Linnet
0.0430	0.2551	0.441	0.1015	397.5	Ibis
0.0357	0.2120	0.430	0.0988	477	Hawk
0.0307	0.1826	0.420	0.0965	558	Dove
0.0268	0.1598	0.412	0.0946	636	Grosbeak
0.0215	0.1284	0.399	0.0912	795	Drake

COMPARISON OF PHYSICAL & ELECTRICAL PROPERTIES OF 795 KCmil CONDUCTORS 26/7 ACSR DRAKE, AAC, AAAC AND ACAR 1.100" DIAMETER (EXCEPT ARBUTUS)

TYPE	ACSR	AAC	AAAC	ACAR		
Code Word (if Any)	Drake	Arbutus	Greeley	-	-	-
Construction	26/7	37W	37W	18/19	24/13	30/7
Standing, No. & Diameter						
1350-H19	26 x .1749"	37 x .1466"	-	18 x .1583"	24 x .1583"	30 x .1583"
6201-T81	-	-	37 x .1583"	19 x .1583"	13 x .1583"	7 x .1583"
Steel	7 x .1360	-	-	-	-	-
Actual Area KCMil						
1350-H19	795,000	795,000	-	451,100	601,400	751,800
6201-T81	-	-	927,200	476,100	325,800	175,400
TOTAL	**795,000**	**795,000**	**927,200**	**927,200**	**927,200**	**927,200**
DC Resistance 20° C (Q/Mt.)	.1135	.1152	.1147	.1061	.1038	.1012
AC Resistance 50° C (Q /Mt.)	.1284	.1310	.1290	.1201	.1176	.1153
Equiv.61% 1350 Area KCMil	795000	795,000	798,000	860,000	881,000	902,000
Weight, Lbs./1,000 Ft						
1350-H19	750	748.3	-	423.5	584.5	705.8
6201-T81	-	-	870.4	446.9	305.9	164.6
Steel	344	-	-	-	-	-
TOTAL	**1094**	**746.3**	**870.4**	**870.4**	**870.4**	**870.6**
Rated Strength-Lbs.	31,500	13,900	30,500	23,400	20,900	19,000
Strength/Weight Ratio	28,900	18,625	35,000	26,880	24,010	21,830

AAAC VERSUS ACSR ELECTRICAL COMPARISON

COMPARISON OF SAG TENSION DATA FOR 795 KCMIL CONDUCTORS 26/7 ACSR DARKE, AAC, AAAC, AND ACAR. 900-FOOT RULING SPAN-NESC HEAVY LOADING

CONDUCTOR TYPE	ACSR	AAC	AAAC	ACAR		
Code Word (if any)	Drake	Arbutue	Greeley	-	-	-
Construction	26/7	37/W	37/W	18/19	24/13	30/7
Size (KCMil)	795	795	927.2	927.2	927.2	927.2
Overall Diameter in inch	1.108"	1.026"	1.108"	1.108"	1.108"	1.108"
Resultant Heavy Loading	2.519	2.135	2.308	2.298	2.298	2.298
Rated Tensile Strength	31,500	13,900	30,500	23,400	20,900	19,000
Init. Max. Loaded Tension	11,572	7,983	11,354	11,200	10,500	10,080
% RTS	36.7	57.4	37.2	47.9	50.5	52.9
Final Sag at 60°F	21.45	27.06	19.45	20	21.7	23.3
Final Sag at 120°F	24.99	30.77	23.92	24.4	25.6	27.4
Final Sag at 212°F	29.29	35.87	29.93	30.4	317	32.9
Weight per 1,000 Ft.	1,094	746.3	870.4	870.4	870.4	870.4

ECONOMIC COMPARISON OF 795 KCMIL CONDUCTOR ACSR DRAKE, AAC. AAAC, AND ACAR 1.108" DIAMETER (EXCEPT ARBUTUS)

FACTOR OR METHOD OF CALCULATION		DRAKE	ARBUTUS 795 KCMil 26/7 ACSR	GREELEY 795KCMil 37W AAC	ACAR 1.108" 18/19	ACAR 1.108" 24/13	ACAR 1.108" 30/7
1. AC Resistance @ 50° C Ω / Mile	R	0.1284	0.1310	0.1290	0.1201	0.1176	0.1153
2. Conductor Weight – (Lbs./Mile)	W	5776	3940	4596	4595	4596	4596
3. Power Loss $I^2R=300^2$ KW/Mile	PL	11.56	11.79	11.61	10.81	10.58	10.38
4. Annual Demand Charge Cost = PL × \$500 × .17 (\$/Mile)	Cd	\$982.60	\$1,002.15	11.61	10.81	10.58	\$882.30
5. Annual Energy Loss: PL × 2650 (kW.h/Mile)	Pel	30,634	31,243	30,766	28,645	28,037	27,507
6. Annual Energy Loss Cost: = Pel × 0.10 (\$/Mile)	Cel	\$306.34	\$312.43	\$307.66	\$286.46	\$280.37	\$275.07
7. Total Annual Loss Costs Cd + Cel (\$/Mile)	C	\$1,288.94	\$1,314.58	\$1,294.51	\$1,205.31	\$1,179.67	\$1,157.37
8. Annual Savings/ cond. Mile \$/Mile Over ACSR	S	-	-\$25.64	\$5.57	\$83.63	\$109.27	\$131.57
9. Press Value of Savings/ COD. Mile Over ACSR $PV=S\frac{1-(1+.08)^{-10}}{.08}$	PV	-	-\$228.71	-\$62.72	\$941.67	\$1,230.38	\$1,481.48
10. Additional Value / Pound of Conductor \$/Lb.	$\frac{PV}{W}$	-	-\$0.07	-\$0.14	\$0.205	\$0.268	\$.322

ECONOMIC COMPARISON OF 795 KCMIL CONDUCTOR ACSR DRAKE, AAC. AAAC, AND ACAR 1.108" DIAMETER (EXCEPT ARBUTUS)

FACTOR OR METHOD OF CALCULATION		ARBUTUS 795 KCMil 26/7 ACSR	GREELEY 795KCMil 37W AAC	ACAR 1.108" 18/19	ACAR 1.108" 24/13
1. Ac Resistance @ 50°C-2/Mile	R	0.1092	0.1100	0.1069	0.1048
2. Conductor Weight - Pounds/Mile	W	5676	4731	5077	5077
3. Power Loss I2R = 3202R-kW/Mile	PL	11.18	11.26	10.95	10.73
4. Annual Demand Charge Cost: Cd = PL x $500 × 0.17 - $/Mile	Cd	$950.30	$957.10	$930.75	$912.09
5. Annual Energy Loss: Pal - PL x 2650-kW. h/Mile	Pel	29,627	29,839	29,017	28,434
6. Annual Energy Loss Cost: Cel = Pel x .010- $Mile	Cel	$296.27	$298.39	$290.10	$284.34
7. Total Annual Loss Costs: Cd + Cel - $/ Mile	C	$1,246.57	$1,255.49	$1,220.92	$1,196.438
8. Annual Savings/cond. Mile, Over ACSR - $Mile	S		$-8.92	$25.65	$50.14
9. Present Value of Savings/cond. Mile Over ACSR $PV \frac{1-(1+.08)^{-10}}{.C8} = (11.26)$	PV		$-100.44	$288.82	$564.58
10. Additional Value/Pound Conductor $/Pound	PV		$-.021	$0.057	$0.111

COMPARISON OF PHYSICAL & ELECTRICAL PROPERTIES OF 954 KCMIL CONDUCTORS 45/7 ACSR RAIL, AAC, AND ACAR 1.165" DIAMETER (EXCEPT MAGNOLIA)

CONSTRUCTION	ACSR	AAC	ACAR	
Code Word (if Any)	Rail	Magnolia	-	-
Construction	45/7	37W	24/13	30/7
Stranding, No. & Diameter.				
1350 - H19	45 x.1456"	-	24 x.1664"	30 x.1664
6201-T81	-	37 x .1606"	13 x.1664"	7x .1664"
Steel	7x .0971"	-	-	-
Actual Area - omil				
1350 - H19	954,000	954,000	664,500	830,670
6201 - T81	-	-	360,000	193,830
TOTAL	**954,000**	**954,000**	**1,024,500**	**1,024,500**
DC Resistance 20°C (Ω/ml)	.0958	.0960	.0937	.0915
AC Resistance 50°C (Ω/ml)	.1092	.110	.1069	.1048
Equiv. 61% 1350 Area Cmil	954,000	954,000	974,000	997,500
Weight Lbs./1,000 Ft.				
1350 - H19	900	896.0	623.8	779.8
6201 - T81	-	-	337.8	181.8
Steel	175	-	-	-
TOTAL	**1,075**	**896.0**	**961.6**	**961.6**
Rated Strength Lbs.	25,900	16,400	22,600	20,400
Strength/Weight Ratio	24,100	18,300	23,500	21,200

COMPARISON OF SAG TENSION DATA FOR 954 KCMIL CONDUCTORS 45 ACSR RAIL AAC, AND ACAR, 1,000-FOOT RULING SPAN - NESC - HEAVY LOADING

CONSTRUCTION	ACSR	AAC	ACAR	
Code Word (if Any)	Rail	Magnolia	-	.
Construction	45/7	37W	24/13	30/7
Size	954 kcmil	954 kcmil	1,024.5 kcmil	1,024.5 kcmil
Overall Diameter	1,165	1,124"	1,165	1,165
Resultant Heavy Loading	2,041	2,343	2,424	2,424
Rated Tensile Strength	25,900	16,400	23,100	20,400
Init. Max. Loaded Tension	10,000	7,885	10,107	9,277
% RTS	38.6	48.1	43.3	45.5
Final Sag at 60° F	34.20	38.69	30.6	33.2
Final Sag at 120° F	37.92	42.11	34.7	37.1
Final Sag at 212° F	43.12	47.0	40.3	42.4
Weight per 1,000 Ft.	1,075	895.5	962	962

Applicable Indian / International Standards References

a. Indian Standards

1.	IS 9997/1991	With latest version for Aluminium Alloy Ingots
2.	IS 504/1963	With latest version for Chemical Analyser
3.	IS 2658/1964	With latest version for Tensile test
4.	IS 3635/1986	With latest version
5.	IS 398(P-IV)/1994	With latest version for AAAC conductor
6.	IS 209-1992	
7.	IS 2633-1990	
8.	IS 1521-1991	
9.	IS 2629.1990	
10.	IS 4826-1992	
11.	IS 6745-1991	
12.	IS 8263-1976	
13.	IEC 1089-1991	
14.	IS 1778/1980	With latest version
15.	IS 1841-1978	
16.	IS 3975	
17.	IS 7623-1985	For lithium base grease Grade-II
18.	IS 5484-1978	
19.	IEC-207-889-1089	
20.	IS 14255.1995	For Arial Bunch Cable
21.	IS 398 (P-1)/1996	
22.	IS 398 (P-2)/1996	
23.	IS 398 (P-5)/1996	
24.	IS 398 (P-6)/2021	

b. International Standards

1. BS-215 (P-1, P-2) 1970
2. BS 4565-1990
3. BS 443-1990
4. BS 183-1982
5. BS 3288
6. ASTM Standard
7. French standard sizes
8. Canadian Standards
9. DIN 48204 10. DIN 48021
11. DIN VDE 0210. 0211, 46391, 48303, 57103
12. BS 3242-1970

IMPORTANT - TERMINOLOGY - PARAMETERS

MODULES OF ELECTRICITY $= \frac{9.9\,m + 28}{m + 1} \times 10^6$ lb / IN^2 (Where m = ratio of Aluminium section to steel section)

α (Coefficient of linear expansion) $= \frac{12.78\,m + 18.1}{m + 2.83} \times 10^{-6}$ per degree F

Weight per ft. per IN^2 $= \frac{1.2.1m + 3.31}{m + 1}$ lb

$d = \frac{Wl^2}{2T}$ Where d= Sag; l = half span; T = permissible line Tension

$W = \sqrt{(w + w_1)^2 + w_w^2}$

W = Total force on conductor; w = Weight of Conductor / ft; w_w = Wind pressure

W_1 = Weight of ice (= p $(0.5\,D + R)^2 - (0.5D)^2 \times \frac{1}{144} \times$ Wight of 1 cu. ft of Ice)

Where

R = Radial thickness of lec;
D = Diameter of conductor

F = Stress (T/a; Tension per unit area);
T = Working Tension of conductor
a = area of cross section of conductor

Reactance calculation :

Single phase : $L = 0.741 \log_{10} \frac{D}{r}$ mH / mile

Three phase : $L = 0.08 + 0.741 \log_{10} \frac{D}{r}$ mH / mile

$X = 2\pi f\, L \times 10^{-3}$ ohms

r = radius
D = Spacing between conductor
L = Inductance
X = Reactance
f = frequency
mH = mili henries

LAY RATIO

Ratio of the Axial Length of complete turn of helix formed by an individual wire in a standard conductor to the external diameter of helix. The axial length of spiral of wire in layer is called a lay and is often expressed as a multiple of mean diameter of the layer containing the wire is called the lay ratio.

- If the lay ratio is t, the length of the wire is $\sqrt{1 + (\pi/r)^2}$ times the axial length.
- Lay ratio factor is often taken as 1.0217
- Stranding causes 2% increase in the resistance.
- Generally resistance of Aluminium wire only is considered, as steel wire offers very high resistance.
- The strength of Aluminium wire ranges from 23000 lb./In^2 (Large wire); 28000 lb./In^2 (Small wire) and of Steel wire 179000 to 200,000 lb./ In^2

LINE CONDUCTORS AND SUPPORTING STRUCTURES

Properties of Stranded Conductors All conductors employed on overhead lines are preferably stranded, on account of the increased flexibility thereby obtained. Solid wires, except in the smaller sizes, are different to handle, and when used for long spans tend to crystallise at the points of support due to swinging in the wind.

In stranded conductors there is generally one central wire, and round this, successive layers of wires containing 6,12,18,24... wires. Thus if there are *n* layers, the total number of individual wires employed is

$$N = 3n\,(n + 1) + 1 \qquad \text{..........97}$$

In the process of manufacture, the consecutive layer of wires are twisted or spiralled in opposite directions, the effect being to bind all the layers together. This method of construction is known as concentric lay.

With very large sections of conductor, however, another method of stranding called 'rope lay' is sometimes used as it gives a more flexible conductor.

When a current enters a stranded conductor it divides among the wires, and each separate current, for all practical purposes, remains in its own wire throughout the length of the conductor. This is because the individual wires being circular touch only along lines, and the surface resistance, due to dirt and the formation of oxide or sulphide, has a fairly high value. The result is that each current, in general, pursues a spiral path of greater length than the length of the conductor as a whole, and this offective increase of the path length correspondingly increases the resistance. The precise magnitude of this effect depends on the lay adopted for the conductor, meaning by this term the axial length of one complete turn of any wire. The lay is usually expressed numerically in terms of the mean diameter of the layer containing the wire.

There is no fixed lay used by all manufacturers, but in wire tables the assumption is usually made that the length, and corresponding resistance, of all wires except the straight central one, is increased by 2% above the values for the central one. This is equivalent to assuming that every twisted wire has a lay ratio of about 15.6.

Another effect of stranding is to modify slightly the fundamental formula for inductance, which is based on a solid round conductor. According to Dwight[1], the inductance per mile of concentric-lay conductor is as follows:-

3-Strand conductor, $L_0 = (0.125 + 0.741 \log_{10} \frac{d}{r})\, 10^{-3}$ henries,

7-Strand conductor, $L_0 = (0.103 + 0.741 \log_{10} \frac{d}{r})\, 10^{-3}$ henries,

19-Strand conductor, $L_0 = (0.089 + 0.741 \log_{10} \frac{d}{r})\, 10^{-3}$ henries,

37-Strand conductor, $L_0 = (0.085 + 0.741 \log_{10} \frac{d}{r})\, 10^{-3}$ henries,

61-Strand conductor, $L_0 = (0.083 + 0.741 \log_{10} \frac{d}{r})\, 10^{-3}$ henries,

Where dis the interaxial distance between conductors, and r is the overall radius of the conductor, both measured in the same units. For conductors having more than sixty-one strands, the formula for solid conductors.

$L_0 = (0.080 + 0.741 \log_{10} \frac{d}{r})\, 10^{-3}$ henries/mile, is used.

Voltage Limitations of Line

The critical voltage limit of a line can be raised by increasing either the spacing or the size of the conductors, but the latter method is preferable as the spacing must be kept down to a minimum value in order to save tower costs, and avoid excessive reactance drop in the line. For increasing the size of the conductors, stranded conductors with hemp centers have occasionally been employed, but have not proved satisfactory from a mechanical point of view owing to the hemp deteriorating rapidly.

Steel-cored aluminium conductors have a much greater diameter than copper ones of the same conductivity, and this consideration often leads to the choice of steel-cored aluminium for systems operating near the corona limit. In a special conductor construction introduced by the Anaconda Wire and Cable Co.. one or more layer of copper strands are spiralled round a core of twisted copper, I-beam in shape. Thus strength is added to the hollow conductor without the addition of dead weight or sacrifice of conductivity or durability. Another design coming into use consists of a number of tongued and grooved rectangular copper sections, which are spiraled along the length of the conductor to form a hollow tube. In general, it is not advisable to operate a line above its fair weather disruptive critical voltage E0 (determined for 25° C and average barometric conditions). If the operating voltage happens to be just below this value the corona losses in fine weather will be negligible. They may, however, have a fairly high value under storm conditions, but, since storms are only experienced at intervals in most districts. it is usually more economical to pay for these losses for small parts of the year than try to eliminate them absolutely by using heavy conductors.

Thermal Current Raring

The steady state thermal rating of a conductor is calculated from the following heat balance equation according to IEE method

$$I^2 r\,Ac + q = q_r + q_c$$

$$I = \sqrt{\frac{q_r + q_c - q_s}{rAC}}$$

Where,

I = steady state current, amps

.r_{ac} = AC resistance of conductor, ohms

q_s = heat gain from the sun

q_r = radiation heat loss

q_c = convection heat loss

AC Resistance of Conductor

$$r_{AC} = Kr_{dc}$$

Where,

r_{dc} = DC resistance at the operating temperature ohms/meter.

K = skin effect factor

The DC resistance at the operating calculated by taking the value of temperature coefficient of resistance as 0.004/°C

Heat gain from sun

q_8 = a Q_8 (sinθ) A' W / meter

Where,

a = coefficient of solar absorption

(= 023 to 0.91)

$\boldsymbol{Q_8}$ = Solar and sky radiated heat,

$\boldsymbol{W/m^2}$

$\boldsymbol{A'}$ = Projected area of conductor, m^2 per lineal meter

Q = Cos^{-1} (cos Hc) cos (Zc-Z1)

Where,

Hc = altitude of sun, degrees

Zc = azimuth of sun, degrees

Z1 = azimuth of conductor, degrees

Radiation Heat Loss

$$q_r = 0.178\ de \left[\left(\frac{tc + 273}{100} \right)^4 - \left(\frac{tc + 273}{100} \right)^4 \right] W/m$$

Where,

d = Conductor diameter, cm

e = coefficient of emissivity

(= 023 to 0.91)

$\boldsymbol{t_c}$ = Conductor temperature, °C

$\boldsymbol{t_a}$ = ambient temperature, °C

Natural Convection (still Wind) Heat Loss

At sea level

$q_{cN} = 0.1174\, d^{0.75}\, (tc\text{-}ta)^{-1.2}\ W/m$

At altitudes above sea,

$q_{cN} = 0.1152\, pf^{0.5}\, (tc\text{-}ta)^{-1.2}\ W/m$

Where,

pf = air density, kg / m^3 at temperature of air film,

$tf = \frac{(tc + ta)}{2}$

Forced Convection (with wind) Heat Loss

$$q_c = \left[1.01 + 4.474 \left(\frac{d\, pf\, V}{f} \right)^{0.52} \right] Kf\,(tc\text{-}ta)\ W/m.$$

Where,
V = wind velocity normal to conductor, km/hour, taken as 2.2.
f = absolute viscosity of air, kg/h, m at tf.

Kf = thermal conductivity of at tf.

Sr. No.	ACSR Conductor Bundle	Thermal Rating			
		75 °C Still Wind		75 °C 2.2 kmph Wind	
		Phase current Amps	Power Limit MVA	Phase current Amps	Power Limit MVA
1	Moose' Twin	504	698	1240	1718
2	Bersmis'Twin	574	795	1432	1984
3	Zebra' Quad	918	1272	2220	3076
4	Moose' Quad	1008	1397	2480	3436
5	Bersmis'Quad	1590	1590	2864	3968

Conductor Bundle Parameters of 400 kV Double Circuit Transmission Lines

Sr. No.	Particulars	Twin Moose	Twin Bersmis	Quad Zebra	Quad Moose	Quad Bersmis
1	2	3	4	5	6	7
1	Thermal Rating in MVA					
	(I) No Wind	698	795	1272	1397	1590
	(II) 2.2 kmph Wind	1718	1984	3076	3436	3968
2	Surge Impedance					
	Loading in MW	1146	1158	1404	1419	1429
3	Interference Performance					
	(I) Max. Conductor Surface Voltage Gradient, kV/cm	17.7	-	13.09	10.21	-
	(II) Corona Extinction Voltage, kV	310	338	399	435	472
	(III) Radio Interference Level, dB	61.1	-	35.9	-	-
4	Capital Cost per km (Rs)	15.96	18.51	23.9	27.74	30.24
5	Annual Operating Cost/km/MW of SIL (Rs)	413	380	410	432	461
6	Annual Operating Cost/km/MW (Rs) at					
	(I) 1000 MVA Power Flow	428	430	490	541	602
	(II) 1400 MVA Power Flow	405	382	410	436	467

CONDUCTOR TEMPERATURE RISE AND CURRENT CARRYING CAPACITY.

In distribution and transmission line design the temperature rise of conductor above ambient while carrying current is important. While power loss, voltage regulation, stability and other factors may determine the choice of conductor for a given line, it is sometimes necessary to consider the maximum continuous current carrying capacity of a conductor. The maximum continuous current rating is necessary because it is determined by the maximum operating temperature of the conductor. This temperature affects the sag between towers or poles and determines the loss of conductor tensile strength due to annealing. For short tie lines or lines that must carry excessive loads under emergency conditions, the maximum continuous current-carrying capacity may be important in selecting the proper conductor.

The following discussion presents the Scouring and Fricke formulas for calculating the approximate current-carrying capacity of conductors under known conditions of ambient temperature, wind velocity, and limiting temperature rise.

The basis of this method is that the heat developed in the conductor by 12R loss is dissipated (1) by convection in the surrounding air . and (2) radiation to surrounding objects. This can be expressed as follows

$$V^2R = (W_c + W_r)A \text{ watts}$$

Where

I = Conductor current in amperes.

R = Conductor resistance per foot.

Wc = Watts per square inch dissipated by convection

Wr = Watts per square inch dissipated by radiation

A = Conductor surface area in square inches per foot of length.

The watts per square inch dissipated by convection, Wc can be determined from the following equation :

$$Wc = \frac{0.0128\sqrt{pv}}{Ta^{0.0128}\sqrt{d}} \Delta t \text{ Watts per square inch}$$

Where

P = pressure in atmospheres (p=1.0 for atmospheric pressure).

V = velocity in feet per second.

T_c = (degree Kelvin) average of absolute temperatures at conductor and air.

d = outside diameter of conductor in inches.

Δt = (degree C) temperature rise.

This formula is an approximation applicable to conductor diameters ranging from 0.3 inch to 5 inches or more when the velocity of air is higher than free convection air currents (0.2 - 0.5 ft/sec.)

The watts per square inch dissipated by radiation W, can be determined from the following equation:

$$Wr = 36.8\,E\left[\left(\frac{T}{1000}\right)^4 - \left(\frac{T_0}{1000}\right)^4\right]$$

(Watts per square inch)

Where

E = relative emissivity of conductor surface

(E = 1.0 for "black body", or 0.5 for average oxidized copper).

T = (degrees Kelvin) absolute temperature of conductor.

T_0 = (degrees Kelvin) absolute temperature of surroundings.

By calculating (Wc + Wr), A, and R, it is then possible to determine I from Eq (75) .The value of R to use is the a-c resistance at the conductor temperature (ambient temperature plus temperature rise) taking into account skin effect as discussed previously in the section on positive and negative-sequence resistances.

This method is, in general, applicable to both copper and aluminium conductors. Tests have shown that aluminium conductors dissipate heat at about the same rate as copper conductors of the same outside diameter when the temperature rise is the same. Where test data is available on conductors, it should be used. The above general method can be used when test data is not available, or to check test results.

The effect of the sun upon conductor temperature rise is generally neglected, being some 3° to 8°C. This small effect is less important under conditions of high temperature rise above ambient.

The tables of Electrical Characteristics of Conductors include tabulations of the approximate maximum current carrying capacity based on 50°C rise above an ambient of 25°C, (75°C total conductor temperature). tarnished surface (E = 0.5), and an air velocity of 2 feet per second. These conditions were used after discussion and agreement with the conductor manufacturers. These thermal limitations are based on continuous loading of the conductors.

The technical literature shows little variation from this condition as line design limits. The ambient air temperature is generally assumed to be 25°C to 40°C whereas the temperature rise is assumed to be 10°C to 60°C. This gives a conductor total temperature range of 35°C to 100°C. For design purpose copper or ACSR conductor total temperature is usually assumed to be 75°C as use of this value has given good conductor performance from an annealing standpoint. the limit being about 100°C where annealing of copper and aluminium begins.

COMPARISON BETWEEN ALUMINIUM AND COPPER

Sr. No.	Particulars	Twin Moose	Twin Bersmis
1	Coefficient of Linear Expansion	23×10^{-6} deg. C	16.6×10^{-6} deg. C
2	Density	2.703 gm/cm³	8.80 gm/cm³
3	Weight of 1 sq. ft.	169.18 lb.	554.98 lb.
4	Modulus of Elasticity	9.9×10^{6}	18×10^{6}
5	Standard Resistivity at 20°C	2.8735 micro Ω/cm³	0.694 micro Ω/cm³
6	Temperature Coefficient of Resistivity	0.00407 per °C	0.004 per °C

Total strength of Aluminium plus steel conductor is found to be 50% of greater than equivalent copper conductor. As such weight of Aluminium conductor is half of copper conductor. Density of steel is taken as 7.80 gm / cm^3

VIBRATION DAMPER DESIGN

Damping constant for high frequency oscillation is defined by 3.26 x V/d cycles / Sec. Where V = Wind Velocity and; d = diameter of conductor

CLEARANCES AT RAILWAY CROSSING

Vertical Clearance

1)	Up to and including 11 kV:	10.95 Mtr (by cable)
2)	Above 11 kV up to 66 kV:	14.10 Mtr
3)	Above 66 kV up to 132 kV:	14.60 Mtr
4)	Above 132 kV up to 220 kV:	15.40 Mtr
5)	Above 220 kV up to 400 kV:	17.90 Mtr

Electrical Clearances (IS 5613)

	66 kV	132 kV	220 kV		400 kV
Ground Clearance (Mtrs)	6.1	6.1	7.015		9.0
Building:					
Vertical (Mtrs)	3.97	4.58	5.49		8.00
Horizontal (Mtrs)	2.14	2.75	3.66		8.00
Between Lines:					
Line to Line (Mtrs)	2.44	3.05	4.58		8.00
ph-ph:			S/C	D/C	
Horizontal (Mtrs)	3.5	6.8	6	8.4	9.00
Vertical (Mtrs)	2.0	3.9	4.9 for both		8.00

- Working Ground Adjustment to the Tower: 5 Mtr
- Explosive Distance: 4.5 Mtr

Forest Way Leave

kV	Right of Way (Mtr) Width (Max)	Vertical Clearance (Mtrs) (1 Tree Top to Conductor)	
11	7	2.6	Power line Crossing Angle 90° - 60°
33	15	2.8	
66	18	3.4	
132	27	4.0	
220	35	4.6	
400	52	5.5	
800	85	-	

MINIMUM CLEARANCE BTW. EHV TELECOM WIRES

Line Voltage	> 36 kV ≤ 72.5 kV	2440 mm (8'0")
	> 72.5 kV ≤ 145 kV	2740 mm (9'0")
	> 145 kV ≤ 245 kV	3050 mm (10'0")
	> 245 and above	3050 (+ 305 mm for every 33 kV & part thereof)

SPAN AND STRUCTURE HEIGHT DETAILS OF EHV LINES - GENERALLY ADOPTED

Sr. No.	Voltage kV	Type of Structure	Span in Meters	Height of Tower Meters	Ground clearance Meter
1.	66 kV Single Circuit	H-Frame	200	11	6.1
2.	66 kV Double Circuit	Tower	260	21	6.1
3.	132 Kv Single/ Double Circuit	Tower	350	30	6.1
4.	220 kV Single/Double Circuit	Tower	350	34	7.1
5.	400 kV Single Circuit	Tower	400 (normal span in open land)	38	6
6.	400 kV Double Circuit	Tower	400-460 Meter	51	9a

CURRENT CARRYING CAPACITY OF BARE OVERHEAD TRANSMISSION LINE CONDUCTORS

1.0 The current carrying capacity (Ampacity) of a bare, overhead transmission line conductor is that current (amps) which may flow in it continuously while maintaining a steady maximum permissible temperature over its surface. The maximum permissible temperature is that which does not permanently and adversely affect the physical properties of the conductor material.

The current carrying capacity of a conductor is based on the concept that under a state of thermal equilibrium, the total heat gained by the conductor due to energy loss (PR) within itself and by solar and sky radiation equals the total heat lost by the conductor by conduction to the metallic supporting it, by convection to the air surrounding it and by radiation to its surrounding objects.

1.1 Factors influencing the steady state

1.1.1 Conductor Material and its physical properties	Material:	Copper, Aluminium, Steel, and their Alloys
	Construction:	Monometal, Composite
	Size:	Overall diameter
	Resistance:	DC and AC resistance at supply frequency and conductor temperature
	Surface condition:	Ability to absorb and emit heat
1.1.2 Geographical	Location:	Altitude of line above sea level Absolute viscosity, density, and thermal conductivity of air
	Position: of line	Altitude of Sun, Azimuth of Sun, Azimuth
1.1.3 Meteorological	Wind Speed:	Laminar or turbulent flow Season of Year
	Ambient temperature:	Time of day

1.2 Except the conductor materials, construction and its diameter which could, perhaps be known to a fair degree of accuracy, none of the other factors are constant at any given point of time and cannot be assessed accurately. A transmission line does not run at the same altitude nor in the same direction throughout its length of several kilometers (often in hundreds) nor the ambient temperature and wind speed could be expected to be same throughout its length. The speed of wind and its turbulence as also the ambient temperature are constantly changing parameters in any given period of time of day or season of a year. So also is the extent of radiation from Sun and Sky. On these counts, the Ampacity of a conductor is not a constant figure but varies according to the prevailing conditions of weather, season and time of day. Ampacity is therefore calculated for certain assumed steady state conditions on an average basis for an assumed maximum conductor temperature as a guide for safe loading of the conductor without affecting its physical properties.

1.3 Several researchers have formulated theories and formulas, which differ from each other, though the basic concept is the same. Many of these formulae are more of academic interest than of practical applications. The effect of Sky radiation, Altitude, position of Sun, orientation of line etc. affect the Ampacity only marginally and many utilities neglect them for Ampacity calculations. One such method is given below for an ACSR conductor of composite construction and a AAAC conductor of Monometal construction, both being of same wire size & same overall diameter.

2.0 Symbols

I = Conductor current, amps at 50 Hz

D = Conductor outer diameter, meters

d = Conductor inner diameter, meters

A = Projected area of conductor per meter length, Sq. m

a = Coefficient of Solar absorption of conductor

e = Coefficient of Emissivity of conductor

a = Constant mass temperature coefficient of resistance of conductor per °C

$R_{dc}/20$ = D.C. resistance of conductor at 20 °C, Ω / km

$R_{dc}/_{tc}$ = D.C. resistance of conductor at temperature t, °C, Ω / km

$R_{ac}/_{tc}$ = A.C. resistance of conductor at 50 Hz and temperature t, °C, Ω / km

t = Average conductor temperature, °C
t = Average ambient temperature, °C
T = Average conductor temperature, Kelvin = t + 273
T = Average ambient temperature, Kelvin = t + 273
T f = Average air film temperature = (t + t) / 2
V = Average velocity of wind, meters/hour
P = Density of air at temp. t , kg/cu. meter
m = Absolute viscosity of air at temp. t , Kgf/hr. (m)
K = Thermal conductivity of air at temp. t , watts/m (°C)
σ = Stefan-Boltzman constant = 5.678×10^{-8} watts/sq. m/°K^4
q = Effective angle of incidence of sun's rays on conductor surface, degrees
S = Direct Solar irradiation on conductor surface, watts/sq. m
S_1 = Sky radiated heat on conductor surface, watts/sq. m
W = Heat gained by conductor by solar radiation per linear meter, watts/Mtr.
W = Heat lost by conductor by convection per linear meter, watts/m.
W = Heat lost by conductor by radiation per linear meter, watts/m.

3.0 FORMULAE

3.1 Fundamental Heat balance equation

$I^2(R_{ac}/t_c)=W_c+W_r-W_s$

Heat lost by conductor by conduction to connected metallic parts is insignificant and therefore neglected.

3.2 Heat gained by conductor due to Solar irradiation

$W_a =$ a(S Sin θ+S^1)D watts/m

Heat gained by sky radiation (S^1) is negligible and hence neglected. For worst condition Sin q = 1. Therefore,

$W_a =$ aSD watts/m. where

a = 0.23 to 0.85 for conductor up to 1 year age and 0.90 to 0.95 for conductor above 1 year age.

3.3 Heat lost by conductor by radiation

Wr = $\varepsilon\sigma\pi D(K_c^4-K_a^4)$watts/m.

ε = 0.17838 x 106xεxD$(K_c^4-K_a^4)$ watts/m. where,

ε = 0.45 for conductor less than 1 year age

0.75 for conductor 1 year to 10 years age

0.85 for conductor over 10 years age

3.4 Heat lost by conductor by convection

3.4.1 Natural Convection loss (wind speed less than 2200 m/hr)

$W_c = 3.71272\, D^{0.75}(t_c-t_a)^{1.25}$ watts/m. at sea level

$W_c = 3.646\,1606\,(p_1)^{0.5}\, D^{0.75}(t_c-t_a)^{1.25}$ watts/m at altitudes above sea level

3.4.2 Forced Convection loss (wind speed 2200 m/hr and above)

$W_{c1} = \{1.00531 + 1.35088\,(D_{pf}V/\mu f)^{0.52}\}\, k_f(t_c - t_a)$ watts/m

$W_{c2} = \{0.75398\,(D_{pf}V/\mu f)^{0.6}\}k_f\,(t_c - t_a)$watts/m

Whichever is higher of the above two equations is to be considered. The values of ρ , μ f, and k at air film temperature, if are taken from Table-1.

3.5 A.C. resistance of conductor

3.5.1 Composite (R_{dc}/20) Conductors (ACSR and AACSR)

$(R_{dc}/t_c) = \{1+a(t_c - 20)\}$ Ω/km where.

a = 0.004 for Aluminium (Ec grade) and ACSR

a = 0.0036 for AAAC and AACSR

$(R_{ac}/t_c) = R_{dc}/t_c\{1+0.00519\,(mr)^n K_1+K_2\}$ where,

mr = $0.050133\,\{f/(R_{dc}/t_c)\}^{1/2}$

= $0.3544938/(R_{dc}/t_c)^{1/2}$

if mr < 2.8

n = 4 0.0616+0.0896 (mr) 0.0513 $(mr)^2$

if mr>2.8 < 50

n = 4+0.5363 - 0.2949 (mr)+0.0097 $(mr)^2$

K1 = $[\cos\{90\,(d/D)^p\}]^{2.35}$ where,

P = 0.7+0.11 (mr) 0.04 $(mr)^2$+0.0094 $(mr)^3$

K2 = 0.15 for single aluminium layer ACSR and AACSR

= 0.03 for three aluminium layer ACSR and AACSR

= 0.003 for two or four aluminium layer ACSR and AACSR

3.5.2 Monometal conductor (AAC and AAAC)

$(R_{ac}/t_c) = (R_{dc}/t_c)(1-Y_s)$ where,

Ys = $(X_s)4/\{192+0.8(X_s)4\}$ where

$X_s^2 = 3\pi f\, 10^4/(R_{dc}/t_c)$

= $0.1256637/(R_{dc}/t_c)$ for f= 50 Hz

3.6 Current carrying capacity of conductor

$$I = \left\{\frac{(W_c + W_r\, W_s)}{(R_{ac}/t_c) \times 10^3}\right\}^{1/2}$$

References:

1. Current Carrying capacity of overhead transmission line conductor for Northern Region CBIP Publication
2. Ampacities for Aluminium and ACSR and overhead Electric conductors Aluminium Association, New York.
3. Current temperature characteristics of Aluminium conductors Alcoa publication, Pittsburgh
4. Design and Construction guide line - Swed Power publication
5. IEEE Standard for calculation of bare overhead conductor temperature and Ampacity under steady state conditions - American National Standard 738 - 1986

AIR PARAMETERS

Air film Temp. t_f °C	Abs. Viscosity of air μ_1 kg/m. hr.	Air Density at sea level P_f kg/cum	Thermal Conductivity of air K_f Watts/sq. m. C
0.00	0.061759	1.2927	0.024245
5.00	0.062650	1.2703	0.024606
10.00	0.063545	1.2478	0.025000
15.00	0.064438	1.2254	0.025361
20.00	0.065330	1.2046	0.025722
25.00	0.066074	1.1854	0.026083
30.00	0.066967	1.1661	0.026476
35.00	0.067860	1.1469	0.026837
40.00	0.068604	1.1277	0.027231
45.00	0.069497	1.1101	0.027592
50.00	0.070390	1.0941	0.027953
55.00	0.071134	1.0764	0.028346
60.00	0.072027	1.0588	0.028707
65.00	0.072771	1.0444	0.029068
70.00	0.073515	1.0300	0.029462
75.00	0.074408	1.0156	0.029823
80.00	0.075152	1.0044	0.030217
85.00	0.075896	0.98674	0.030577
90.00	0.076640	0.97393	0.030938
95.00	0.077533	0.95951	0.031234
100.00	0.078277	0.94669	0.031693

EXAMPLES

Example 1: Ampacity of 54 (Al) + / -7 (st) / 3.18 mm 'Zebra" AC

Data:	Conductor constuction	54 (alm) + 7 (Steel)/3.18 mm ACSR
	Conductor diameter (outer)	D = 0.02862 m
	Conductor diameter (inner)	d = 0.00954 m
	Conductor dc resistance at 20 °C	R_{dc}/20 = 0.069 15 Ω/km
	Solar absorption Coefficient	a = 0.8
	Emissivity Coefficient	a = 0.45
	Final Conductor Temp.	t_c = 75 °C
	Final Conductor Temp.	K_c = 348 K
	Ambient Temp.	t_a = 40 °C
	Ambient Temp.	K_a = 313K
	Solar radiation	S = 1164 Watts/Sq. m.
	Wind Velocity	V = 2200 m/hr

1 Heat gained by solar irradiation (W)

W_s = aSD = 0.8 x 1164 x 0.02862 = 26.650944 W/m

2 Heat lost radiation (W_r)

W_r = 0.17838×10^{-6} (Kc^4 Ka^4) x D x e

= $0.17838 \times 10^{-6} \times (348^4 - 313^4)$ x 0.02862 x 045 = 11.643584 W/m

3 Heat lost by convection (W_c)

Average Temp. $t_f = (t_c + t_a)/2$ = (75+40)/2 = 57.5 °C

From Table 1, by interpolation

μ_f = 0.0715806

P_f = 1.0676

K_f = 0.0285265

$(Dp_fV)/f$ = (0.02862 x 1.0676 x 2200)/ 0.0715806 = 939.08638

W_{c1} = $\{ 1.00531 + 1.35088 (Dp_f\ V/m_f)^{0.52} \} K_f \times (t_c - t_a)$

= $\{ 1.00531 + 1.35088 (939.08638)^{0.52} \}$ x 0.0285265 x (75-40)

= 48.399565 W/m

W^{c2} = $\{ 0.75398 \times (Dpf\ V/\mu_f)^{0.6} \} \times K_f \times (t_c - t_a)$

= $\{ 0.75398 \times (939.08638)^{0.6} \}$ x 0.0285265 x (75 - 40)

= 45.750731 W/m

Therefore,

W_c = 48.399565 W/m (Higher of the two values)

4 Conductor AC resistance at final temperature

$R_{dc}/t_c = R_{dc}/75 = R_{dc}/20$ {1+0.004 (75-20)}

Therefore,

$R_{dc}/75$ = 0.06915 x 1.22 = 0.0843963Ω/km

d/D = (3.18 x 3) / (3.18 x 9) = 3/9

mr = $0.050133 \{f/(R_{dc}/t_c)\}^{1/2}$ f = 50 H_3

= $0.3544938 / (0.084363)^{1/2}$ = 1.2204855 < 2.8

Therefore,

n = $4 - 0.0616 + 0.0896 (mr) - 0.0513 (mr)^2$

= $4 - 0616 + 0.0896 \times 1.2204855 - 0.0513 (1.2204855)^2$

= 3.9713398

P = $0.7 + 0.11 (mr) - 0.04 (mr)^2 + 0.0094 (mr)^3$

= 0.7 + 0.11 (1.2204855) - 0.04 (1.2204855)2 + 0.0094 (1.2204855)3

= 0.7917593

K_1 = $[Cos \{90 \times (d/D)^p\}]^{2.35}$

= $[Cos \{90 \times (3/9)^{0.791593} \}]^{2.35}$

= 0.5765547

K_2 = 0.03 (for 3 aluminium layer ACSR)

R_{ac}/t_c = $R_{ac}/t_c (1 + 0.00519 (mr)^n K_1 + K_2$

Therefore,

$R_{ac}/75$ = $R_{ac}/75 \{ 1+ 0.00519 (mr)^n K_1 + K_2 \}$

= $0.084363 \{ 1 + 0.00519 \times (1.2204855)^{3.9713398} \times 0.5765547 + 0.03 \}$

= 0.0874508 Ω/km

5 Current Carrying Capacity

$= \{ (W_C + W_R - W_S) / (R_{ac}/t_c \times 10^{-3}) \}^{1/2}$

$= \{ (48.399565 + 11.643584 - 26.650944) / 0.0874508 \times 10^{-3} \}^{1/2}$

= 617.93196 or say 618 Amps.

Example 2

Ampacity of AAAC Conductor of Same construction 61/3.18 mm

$R_{dc}/20$	= 0.0705402 (maximum) Ω/km		
$R_{dc}/75$	$= 0.0705402 \times \{1 + 0.0036 (75 - 20)\}$		
	= 0.0845071 Ω/km		
$X_s^{\ 2}$	$= 4\pi 10^{-2} / (R_{dc}/75$	$= 4_p 10^{-2} / 0.0845071$	= 1.4870178
Y_s	$= X_s^{\ 4} / \{ 192 + 0.8 \times {}_s^{\ 4} \}$	= 0.0114116	
$R_{ad}/75$	$= R_{dc}/75 (1 + Y_s)$	= 0.0854714 Ω/km	

Current Carrying Capacity

$= \{ 33.392205 / (0.0854714 \times 10^{-3})^{1/2}$

= 625.04623 Amps or say, 625 Amps.

Inference

a. AAAC can carry 1.13% higher current than ACSR of same construction and size, for the same maximum temperature.

b. AAAC has 2.26% lesser energy loss than ACSR of same construction and size, the same current.

SAG AND TENSION IN CONDUCTORS

1 Indian Electricity Rules 1956, IS 802/1977 and IS 5613/1985 specify the following maximum limits of tension in conductors of transmission lines.

a. At minimum temperature and 2/3 maximum wind pressure 50%

b. At every day temperature of 32 °C and maximum wind pressure 50%

c. At every day temperature of 32 °C and still wind 25%

I. E. Rules 77 to 80 & 87, the PTCC Manual and The Railway Regulations 1987 for placing power lines across tracks specify the minimum clearance from the nearest power conductor to ground, to buildings, between power lines, over telecom lines and over rail tracks, etc.

IS 5613/85 further stipulates that the maximum sag in the ground wire (Earth wire) shall not exceed 90 percent of sag in power conductor for the entire operating temperature range, under steel wind.

A simple, step by step method of calculating sags and tensions in conductors and ground wires for different operating temperatures and wind conditions is given below. Parabolic formula is adopted as commonly in use.

Symbols

D	=	Overall diameter of conductor (m)
A	=	Cross sectional area of conductor (Sq. cm)
W	=	Linear mass of conductor (Kgf/m)
δ	=	Linear mass of conductor per meter per unit sectional area
	=	W/A Kgf/Sq. cm/m
U	=	Ultimate tensile strength of conductor (Kgf)
E	=	Modulus of Elasticity (final) of conductor (Kgf/Sq. cm)
α	=	Coefficient of linear expansion of conductor (per °C)
L	=	Span (m)
P_1	=	Maximum wind pressure on conductor (Kgf/ sq. m)
P_2	=	Wind load on conductor at minimum temperature, per meter length (kgf/m)

P_3	=	Wind load on conductor at 32 °C per meter length (Kgf/m)
t_1	=	Initial conductor temperature (°C)
t_2	=	Final conductor temperature (°C)
Q_1	=	Still wind loading factor (1)
Q_3	=	2/3 Maximum wind loading factor
Q_3	=	Maximum wind loading factor
F_1	=	Initial stress in conductor at temperature t_1 Kgf/ sq. m (Tension per unit area)
F_2	=	Final stress in conductor at temperature t_2 (Kgf/Sq. cm)
T_1	=	Initial tension in conductor at temperature $t_1 = f_1 \times a$ (Kgf)
T_2	=	Final tension in conductor at temperature $t_2 = f_2 \times a$ (kgf)
K	=	Stress Constant
S_1	=	Sag at initial condition T_1 (m)
S_2	=	Sag at final condition T_2 (m)

4 Parameters

Calculation of the following parameters before hand makes calculation simpler and easier.

4.1 Weight Factor

$\delta = W/A$(kg/sq.cm/m)

4.2 Wind Factors

(a)	Wind pressure		P_1=Kgf/sq.mP
(b)	Wind load	2/3 Max.	$P_2 = 2/3\, P_1 \times \delta \times 1$ (kgf/m)
	(On conductor)	Max.	$P_3 = P_1 \times \delta \times 1$ (kgf/m)

4.3 Loading Factors:

Still wind	$q_1 = 1$
2/3 full wind	$q_2 = \{1 + (P_2 \times W)^2\}^{1/2}$
	$q_3 = \{1 + (P_3 \times W)^2\}^{1/2}$

4.4 Temperature Factors

$E\alpha t = E\alpha(t_2 - t_1)$

4.5 Tension Factors

Still wind condition $= \dfrac{L^2 \delta^2 E q_1^2}{24}$

2/3 full wind condition $= \dfrac{L^2 \delta^2 E q_1^2}{24}$

Full wind condition $= \dfrac{L^2 \delta^2 E q_1^2}{24}$

4.6 Sag Factors

Still wind condition $= \dfrac{L^2 \delta E q_1}{8}$

2/3 full wind condition $= \dfrac{L^2 \delta E q_2}{8}$

Full wind condition $= \dfrac{L^2 \delta E q_3}{8}$

4.5 Tension Factors

$$K = f_1 \quad \frac{L^2 \delta^2 E q^2}{24\,(F_1)^2}$$

Where q represents any one of factors q1, q2, and q3 depending on initial conditions assumed.

The application of the various parameters in calculation of Sags and corresponding tensions under different temperatures and wind conditions is explained in the example.

EXAMPLE

5.1 **Data**

5.1.1 **Conductor 61/3. 19 mm AAAC**

Overall diameter	D	=	0.02871 m
Sectional Area	A	=	4.875 Sq. cm.
Weight	W	=	1.345 kg/m
Ultimate Tensile Strength (UTS)	U	=	13154 Kgf
Modulus of Elasticity (final)	E	=	0.55×10^6 Kgf/ sq. m
Coefficients of Linear Expansion	a	=	23x 10.6 per °C.
Limiting tension			

32 °C nil wind
0 °C 2/3 full wind
32 °C full wind

5.1.2 Normal span

L = 350m

5.1.3 Maximum wind pressure

P_1 = 45 Kgf/sq. m

5.1.4 Initial conductor temperature

t_1 = 32°C

5.1.5 Final conductor temperature t_2

Minimum	0 °C
Intermediate	32 °C
Intermediate	53 °C
Maximum	75 °C

5.2 Parameters

5.2.1 Weight factor

δ = W/A
= 1.345 / 4.875
= 0.2759 (kgf/ Sq. cm/m)

5.2.2 a) Wind load on conductor

At 2/3 Maximum wind pressure	P2	=	2/3 x 45 x 0.02871 x 1
		=	0.8613 (kgf/m)
At Maximum wind pressure	P3	=	45 x 0.02871 x 1
		=	1.2920 (kgf/m)

b) Wind factors

Still wind q_1	=	1
2/3 Max.wind q_2	=	$\{1 + (P_2/w)^2\}^{1/2}$
	=	$\{1 + (0.8613/1.345)^2\}^{1/2}$
	=	1.1875
Full Wind q_3	=	$\{1 + (P_3 + /W^2)\}^{1/2}$
	=	1.3866

5.2.2 Temperature Factors

Ea t_{32}	=	0 (Starting condition assumed at 32 °C)
Ea t_o	=	0.55 x 106 x 23 x 106 x (0 - 32) = (-) 404.80
Ea t_{53}	=	0.55 x 106 x 23 x 106 x (53 - 32) = 265.65
Ea t_{25}	=	0.55x 106x 23x 106x (75 - 32) = 543.95
Ea t_{90}	=	0.55 x 106 x 23 x 106 (90 - 32) = 733.70

5.2.4 Tension Factors

At still wind $(L^2\ \delta^2\ E\ (q_1)^2)\ /\ 24$	=	$350^2 \times 0.2759^2 \times 0.55 \times 10^6 \times 1/24$
	=	213.6933×10^6
At 2/3 full wind $(L^2\ \delta^2\ E\ (q_2)^2)\ /\ 24$	=	$213.6933 \times 10^6 \times 1.1875^2$
	=	301.3238×10^6
At full wind $(L^2\ \delta^2\ E\ (q_3)^2)\ /\ 24$	=	$213.6933 \times 10^6 \times 1.38666^2$
	=	410.8595×10^6

5.2.5 Sag Factors

At still wind $(L^2\ \delta q_1)\ /\ 8$	=	$(350^2 \times 0.2759 \times 1)\ /\ 8$
	=	4224.7188
At 2/3 full wind $(L^2\ \delta q_2)\ /\ 8$	=	4224.7188×1.1875
	=	5016.8535
At full wind $(L^2\ \delta q_3)\ /\ 8$	=	4224.7188×1.3866
	=	5857.9950

5.3 Sags and Tensions

For most conductors, the tension limitation at 32 °C, still wind is the controlling factor. Hence the same is assumed as the starting condition.

5.3.1 At 32 °C still wind (Starting condition Assumed)

T_1	$= U/4$	= 13154 / 4
		= 3288.50 kgf
f_1	$= T_1/A$	= 3288.50 / 4.875
		= 674.5641
		= kgf/Sq. cm
S_1	$= (L^2\ \delta q_1)\ /\ 8f_1$	= 4224.7188 / 674.5641
		= 6.2629 m
Result	T_{32}/q_1	= 3288 kgf
	S_{32}/q_1	= 6.26 m

We now find stress constant K given by the formula

K	=	$f_1 - (L^2\ \delta^2 E\ q_1^2)\ /\ 24f_1^2$
	=	$674.5641 - (213.6933 \times 10^6)\ /\ (674.5641)^2 = 204.9464$
K	=	204.9464

5.3.2 At 53 °C still wind

$f_2^2\ \{ f_2 - (K - E\alpha t_{53}) \} = (L^2\ \delta^2 E\ q_1^2)\ /\ 24$

$f_2^2\ \{ f_2 - (204.9464 - 265.65) \} = 213.6933 \times 10^6$

$f_2^2\ \{ f_2 + (60.7036) \} = 213.6933 \times 10^6$

By trial and error with the help of a Scientific calculator

f_2 = 578.2914 kgf/sq. m

$T_2 = F_2 \times A$
= 578.2914 × 4.875
= 2819.1705 kgf

Sag S_2 $= (L^2\ \delta q_1)\ /\ 8f_2$
= 4224.7188 / 578.2914
= 7.3055 m

Result	T_{53}/q_1	= 2819 kgf
	S_{53}/q_1	= 7.31 m

5.3.3 At 75 °C still wind

$f_2^2\ \{ f_2 - (K - E\alpha t_{75}) \} = (L^2\ \delta^2 E\ q_1^2)\ /\ 24$

$f_2^2\ \{ f_2 - (204.9464 - 543.95) \} = 213.6933 \times 10^6$

$f_2^2\ \{ f_2 + 339.0036 \} = 213.6933 \times 10^6$

f_2 = 503.5983 kgf/Sq. cm

$T_2 = F_2 \times A = 503.5983 \times 4.875 = 2455.0417$ kgf

Sag $S_2 = (L^2\ \delta q_1)\ /\ 8f_2 = 4224.7188\ /\ 503.5983 = 8.3891$ m

Result	T_{75}/q_1	= 2455 kgf
	S_{75}/q_1	= 8.39 m

5.3.4 At 90 °C NIL wind condition

$f_2^2 \{ f_2 - (K - E\alpha t_{90}) \}$	$= (L^2 \delta^2 E q_1^2) / 24$	
$f_2^2 \{ f_2 - (204.9464 - 733.70) \}$	$= 213.6930 \times 10^6$	
$f_2^2 \{ f_2 + 528.7536 \}$	$= 213.6930 \times 10^6$	
f_2	= 463.9624 Kgf/Sq. cm	
T_2	$= f_2 \times A$	
	$= 463.9624 \times 4.875$	
	= 2261.8167 kgf	
Sag S_2	$= (L^2 \delta q_1) / 8f_2$	$= \frac{4224.7188}{463.9624}$
	= 9.1057 m	
Result	T_{90}/q_1	= 2262 kgf
	S_{90}/q_1	= 9.11 m

5.3.5 At 0 °C 2/3 full wind

$f_2^2 \{ f_2 - (K - E\alpha t_0) \}$	$= (L^2 \delta^2 E q_1^2) / 24$
$f_2^2 \{ f_2 - (204.9464 + 404.80) \}$	$= 301.3238 \times 10^6$
$f_2^2 \{ f_2 - 609.74674 \}$	$= 301.3238 \times 10^6$
f_2	= 946.26446 kgf/sq. m
T_2	$= f_2 \times A$
	$= 946.26446 \times 4.875$
	= 4613.0392 kgf
F.O.S	$= U/T_2 = 13154/4613$
	= 2.8515 > 2.00 min. required
Sag (deflected) S_2/d	$= (L^2 \delta q_3) / 8f_2$
	= 5016.8535 / 946.2645
	= 5.3017 m
Angle of deflection q	$= \tan^{-1}(P_2/W)$
	$= \tan^{-1}(0.8613 / 1.345)$
	= 32.6344 degrees from vertical
θ	
Sag (Vertical)	S_2/V
	$= S_2/d \times \cos\theta$
	= 5.3017 Cos (32.6344)
	= 4.4647 m
Result	T_0/q_2 = 4613 Kgf
	S_0/q_2 = 4.46 m

.3.6 53.6 At 32 °C full wind

$f_2^2 \{ f_2 - (K - E\alpha t_{32}) \}$	$= (L^2 \delta^2 E q_3^2) / 24$
$f_2^2 \{ f_2 - (204.9464 - 0) \}$	$= 410.8595 \times 10^6$
$f_2^2 \{ f_2 - 204.9464 \}$	$= 410.8595 \times 10^6$
f_2	= 818.3889 kgf/sq. cm
T_2	$= f_2 \times A$
	$= 818.3889 \times 4.875$
	= 3989.6458 kgf
F.O.S.	$= U/T_2$
	= 13154 / 3989.6458
	= 3.297 > 2.00 hence
Sag (deflected) S_2/d	$= (L^2 \delta q_1)$ s/8
	= 4224.7188 / 463.9624

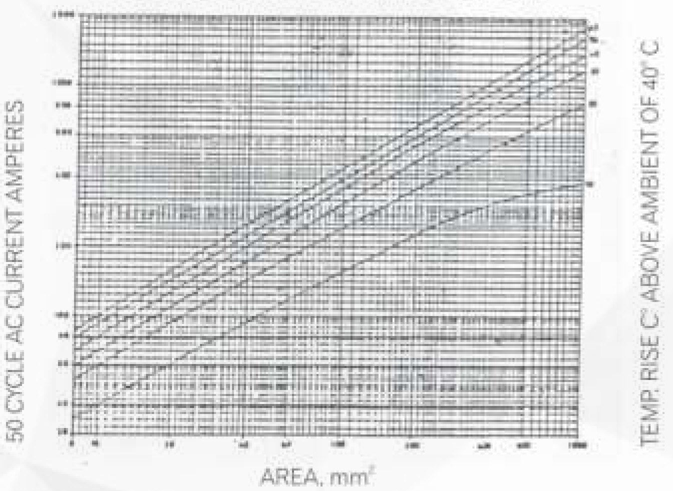
Angle of deflection θ	$= \tan^{-1}(P_3/W)$	
	$= \tan^{-1}(1.2920 / 1.345)$	
	= 43.8486 degrees from vertical	
θ		
Sag (Vertical)	$= S_2/V$	
	$= S_2/d \cos\theta$	
	= 7.1580 Cos (43.8486)	
	= 5.1622 m	
Result	T_{32}/q_3	= 3990 kgf
	S_{32}/q_3	= 5.16 m

CURRENT CARRYING CAPACITY OF OVERHEAD CONDUCTORS

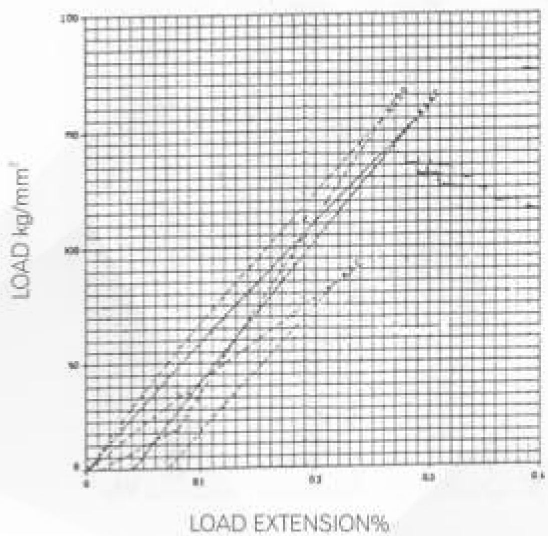
The continuous current carrying capacity of a conductor is limited by the conductor temperature rise above ambient air temperature to a maximum value that is considered safe under continuous operating conditions. For calculating the current ratings of overhead lines, ambient air temperature of 40 °C, is usually assumed. The maximum safe continuous operating temperature for bare conductor is limited to 100 °C because of the effect of high temperatures on the mechanical properties of the conductor material, i.e., tensile strength and elongation. If aluminium wire is maintained at a constant temperature of 100 °C for approx. 4 months, the limited amount of annealing which will take place will be sufficient to reduce the ultimate tensile strength of the aluminium strands, by amounts up to about 10%. The actual amount varies for different wire sizes and those, which have the most cold work, and thus the highest ultimate tensile strength will suffer the greatest reduction.

The temperature rise curves given in the attached graphs apply to a wide range of conductors. These curves show current in Amperes as a function of conductor temperature rise above an ambient air temperature of 40 °C with cross wind velocity of 0.061 meter per second.

AAAC - HS CURRENT CARRYING CAPACITY



TYPICAL STRESS - STRAIN CURVES



LOADING CONDITIONS

To avoid breaking of conductors under severe weather conditions, they must be installed with certain predetermined tensions. The loading on a conductor is the resultant loading due to its weight and weight of any ice and the wind load. Certain formulae are available by which ice loads and wind on conductors can be calculated.

Weight of ice covering on conductor

(Assuming ice to weigh 56 lbs./cu.ft.)

$W_i = 1.224\,(d + t)\,t$ lbs./lineal foot

Vertical wt. of conductor and ice covering

$W_y = W + Wi$ lbs./lineal foot

Horizontal wind load on conductor

$W_h = \frac{(d + 21)\,F}{12}$ lbs./lineal foot

Resultant load on conductor = $W_y2 + Wh2$

Where

W = weight of conductor in lbs./lineal foot

d = diameter of conductor in inches

t = radial thickness of ice in inches

F = wind pressure on bare or ice-covered conductor in lbs./square foot

Loading

True wind velocity is very difficult to measure and hence a correction factor must be applied to the wind velocity indicated by an anemometer.

The maximum wind pressure is calculated using the formula $F = KV^2$

Where,

F = wind pressure in lb./sq. ft.

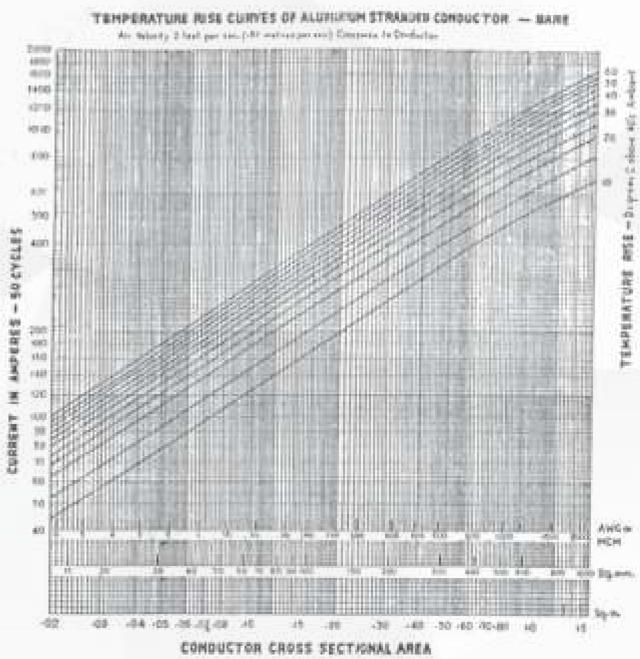
V = actual wind velocity in miles per hour

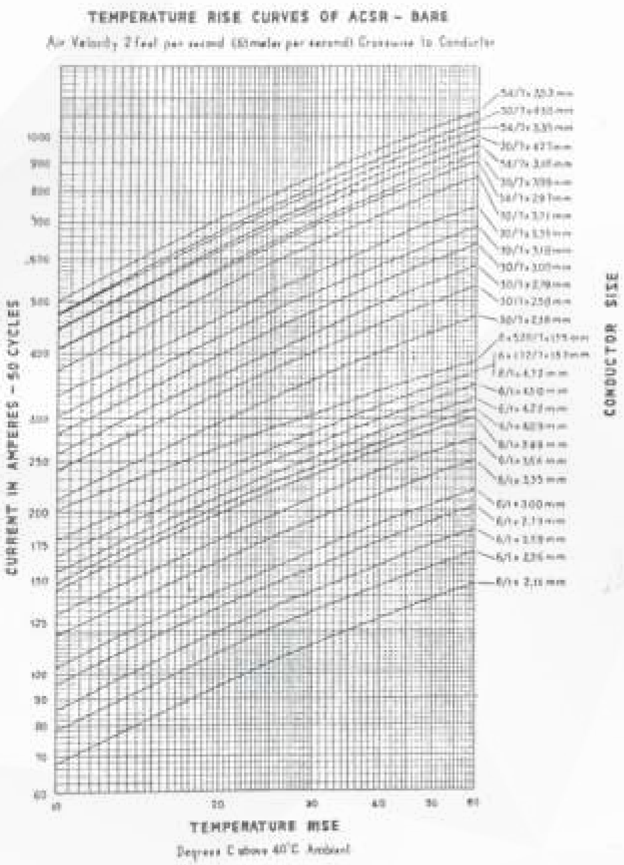
The value k is not strictly constant and depends on the shape and nature of the surface, barometric pressure,and wind velocity.

The following approximate values are used:

For cylindrical surfaces k = 0.0025

For flat surfaces k = 0.0042





BASIC DATA ASSUMED FOR CALCULATION

1. Sag - Tension

Conductor Type	Construction (AL + ST) / AAA Wire Nos. / Nos.	Mod. of Elasticity (kg/sq. cm)	Co-Efficient of Linear Expansion (per °C)
ACSR & AACSR	6+1	0.8055×10^{6}	19.1×10^{-6}
	6+7	0.7750×10^{6}	19.8×10^{-6}
	26+7	0.8158×10^{6}	18.9×10^{-6}
	30+7	0.8158×10^{6}	17.8×10^{6}
	42+7	0.7546×10^{6}	21.5×10^{6}
	54+7	0.7036×10^{6}	19.3×10^{6}
AAAR & ACAR	3	B) 0.6500×10^{6}	23.0×10^{6}
	7	A) 0.6000×10^{6}	23.0×10^{6}
	7	B) 0.6324×10^{6}	23.0×10^{6}
	19	A) 0.5700×10^{6}	23.0×10^{6}
	37	B) 0.5700×10^{6}	23.0×10^{6}
	37	B) 0.5814×10^{6}	23.0×10^{6}
	61	A) 0.5500×10^{6}	23.0×10^{6}
	61	B) 0.5508×10^{6}	23.0×10^{6}

(2) Current Carrying Capacity

Solar Absorption Constant: A = 0.5

Emissivity Constant: E = 0.5

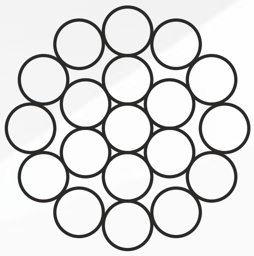
Solar Irradiation: S = 985 Watts / Sq. m.

Wind Velocity: V = 2200 M / Hr.

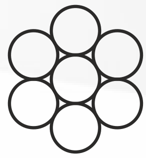
Ambient Temperature: Ta = 40°C

Height: MSL

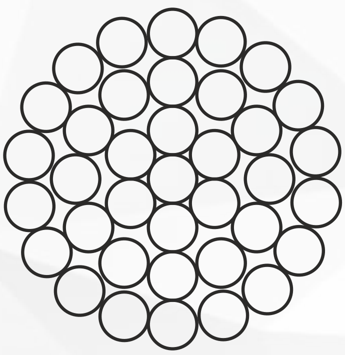
CONFIGURATION DRAWINGS FOR AAC



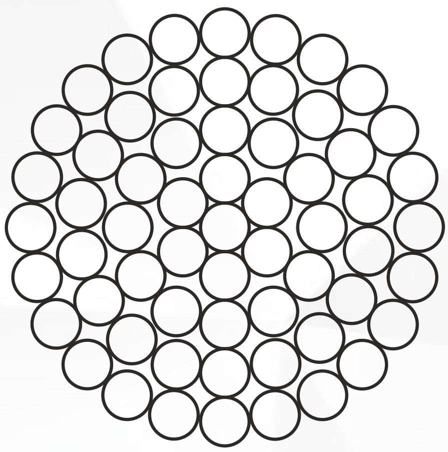
19 Al.



7 Al.



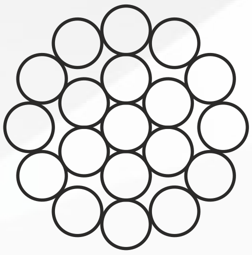
37 Al.



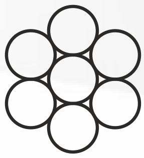
61 Al.

All Aluminium Conductors

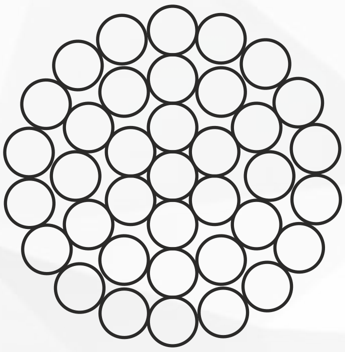
CONFIGURATION DRAWINGS FOR AAAC



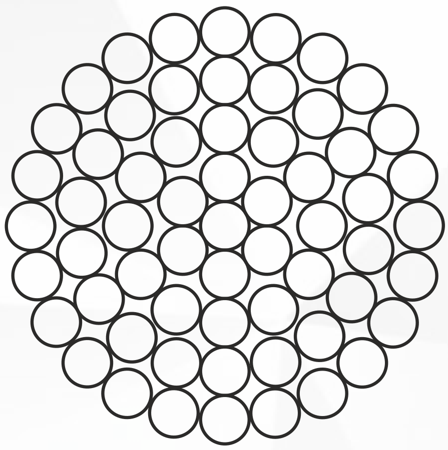
19 Al.



7 Al.



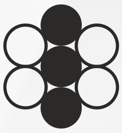
37 Al.



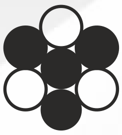
61 Al.

Aluminium Alloy Conductors

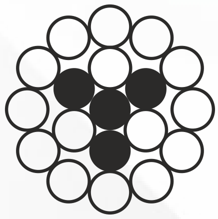
CONFIGURATION DRAWINGS FOR AAC, AAAC & ACSR



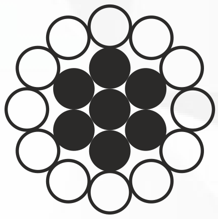
4-Al. / 3-Steel



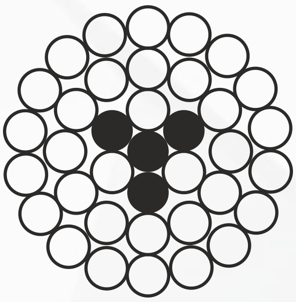
3-Al. / 4-Steel



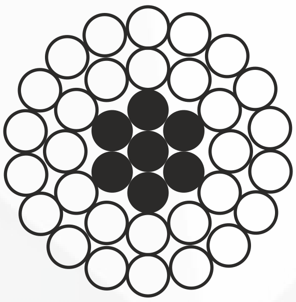
15-Al. / 4-Steel



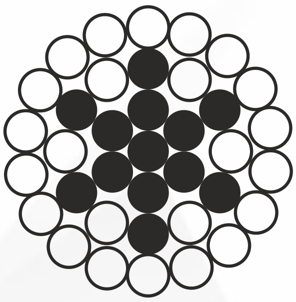
12-Al. / 7-Steel



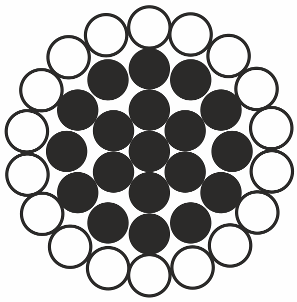
33-Al. / 4-Steel



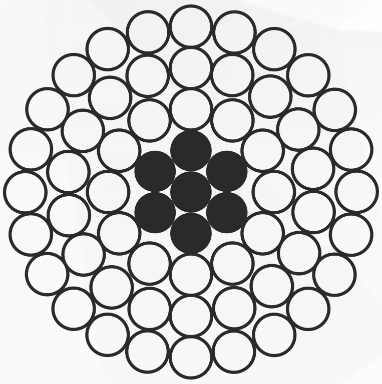
30-Al. / 7-Steel



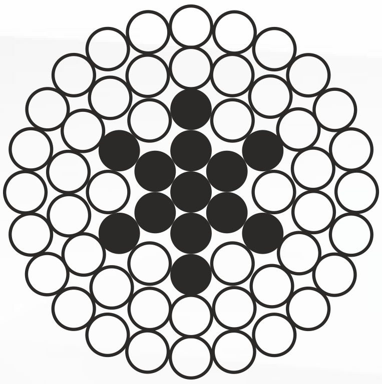
24-Al. / 13-Steel



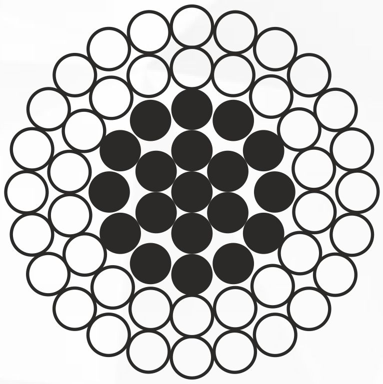
18-Al. / 19-Steel



54-Al. / 7-Steel



48-Al. / 13-Steel

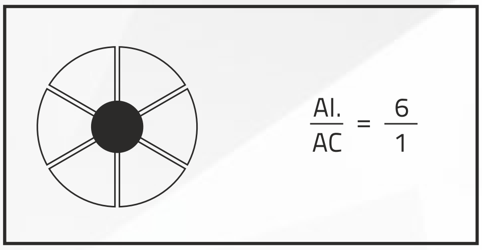


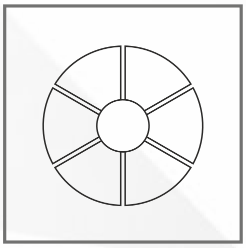
42-Al. / 19-Steel

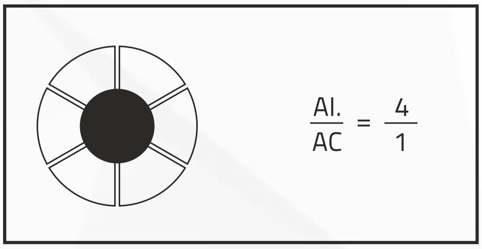
Aluminium Wire   Steel Wires

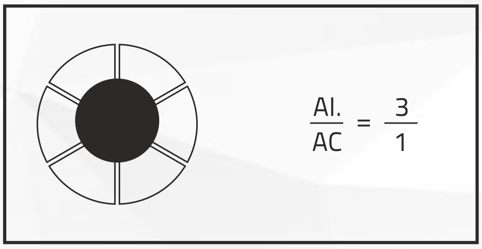
Typical Strandings for Concentric Lay-Stranded ACSR Conductors

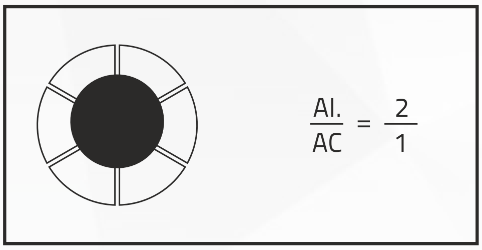
CONFIGURATION DRAWINGS FOR TW/ACCC











Compressed Aluminium Conductor Steel Reinforced and All Aluminium Conductor

VARIOUS INDIAN STANDARDS

ALL ALUMINIUM ALLOY CONDUCTORS (AAAC) REC. spn. 33/1991 (R) & Sizes to IS 398 (Part IV): 1994

Mechanical Parameters

Sr. No.	EQVT. ACSR Code	Nom. Alloy Area	Stranding and wire diameter	Section Area	Approximate		Rated Strength		Span	Tension				Sag		
					OD	Mass				32°C	0°C with wind			53°C	75°C	90°C
														Nil wind		
		sq. m	Nos./mm	sq. mm	mm	kg/km	kn.	Kgf	m	Kgf	Kgf	Kgf	Kgf	m	m	m
											Wind pressure kg/sq. m 50	75	100			
1	Mole	15	3/2.50	14.73	5.39	40	4.33	442	67	111	196	211	227	0.33	0.63	0.90
2	Squirrel	20	7/2.00	21.99	6.00	60	6.45	658	67 107	165 165	279 292	292 320	309 348	0.33 0.79	0.61 1.25	0.87 1.68
3	Weasel	34	7/2.50	34.36	7.50	94	10.11	1031	67 107	258 258	427 444	442 472	460 506	0.32 0.78	0.61 1.24	0.86 1.59
4	Rabbit	55	7/3.15	54.55	9.45	149	16.03	1635	67 107 125	409 409 692	674 686 737	690 720 788	710 763 1.05	0.33 0.73 1.58	0.62 1.15 1.98	0.84 1.61
5 6	Raccoon Dog	80 100	7/3.81 7/4.26	79.81 99.77	11.43 12.78	218 273	23.41 29.26	2387 2984	125 125	597 746	990 1226	1040 1278	1097 1340	1.05 1.05	1.58 1.58	1.98 1.98
7	Dog (up)	125	19/2.89	124.60	14.45	342	36.64	3736	125	934	1507	1561	1627	1.05	1.56	1.95
											Wind pressure kg/sq. m 43	45	52			
8	Dog (up)/ Coyote	150	19/3.15	148.10	15.75	407	43.50	4436	260 275	1109 1109	1743 1740	1755 1753	1798 1800	3.92 1.33	4.85 5.30	5.47 5.95
9	Wolf	175	19/3.40	172.50	17.00	474	50.54	5154	260 275	1289 1289	2002 2002	2020 2015	2065 2068	3.93 4.34	4.86 5.30	5.49 5.98
10	Wolf (up)	200	19/3.66	199.90	18.30	549	58.66	5982	260 275	1496 1496	2306 2298	2319 2312	2363 2363	3.92 4.34	4.85 5.30	5.45 5.95
11	Panther	230	19/3.94	231.70	19.70	637	68.05	6939	320	1735	2609	2627	2693	5.69	6.76	7.47
12	Panther (up)	290	37/3.15	288.30	22.05	704	84.71	8638	320	2160	3163	3181	3249	5.68	6.73	7.43
13	Panther (up)	345	37/3.45	345.90	24.15	953	101.58	10358	320	2590	3754	3773	3844	5.68	6.73	7.43
14	Kundah	400	37/3.71	400.00	25.97	1102	117.40	11971	350 380	2993 2993	4255 4207	4277 4232	4360 4324	6.69 7.76	7.80 8.94	8.54 9.72
15	Zebra	465	37/4.00	465.00	28.00	1281	136.38	13907	350	3477	4905	4928	5013	6.69	7.80	8.54
16	Zebra (UP)	525	61/3.31	525.00	29.79	1448	146.03	14891	380 380	3723 3723	5176 5106	5100 5132	5288 5288	6.99 6.99	8.08 8.08	8.81 8.81
17	Moose	570	61/3.45	570.20	31.05	1574	158.66	16179	380 400	4045 4045	5522 5472	5549 5501	5649 5608	8.13 8.12	9.27 9.27	10.03 10.03
18	Morkulla	605	61/3.55	603.80	31.95	1666	167.99	17130	380 400	4283 4283	5831 5778	5858 5807	5959 5914	8.12 8.13	9.27 9.27	10.03 10.03
19	Moose (up) Morkulla (up)	640	61/3.66	641.80	32.94	1771	178.43	18195	380 400	4549 4549	6175 6117	6202 6146	6304 6255	8.13 8.93	9.28 10.11	10.03 10.89
20	Morkulla (up)	695	61/3.81	696.50	34.29	1919	193.25	19706	380 400	4927 4927	6663 6598	6690 6628	6794 6738	8.13 8.93	9.28 10.11	10.03 10.89
21	Bersimis	765	61/4.00	766.50	36.00	2116	213.01	21721	380 400	5430 5430	7314 7241	7342 7270	7447 7382	8.14 8.94	9.28 10.12	10.04 10.90

Rate: EDT = 25% of Rated Strength

ALL ALUMINIUM ALLOY CONDUCTORS (AAAC) REC Spn. 33/1991/(R) & Sizes for IS 398 (Part IV) 1994

Mechanical Parameters

Sr. No.	EQVT. ACSR Code	Nom. Alloy Area	Stranding and wire diameter	DC Resistance a) Standard b) Maximum	AC Resistance at			Current Capacity		
					65 °C	75 °C	90 °C	65 °C	75 °C	90 °C
		sq. m	Nos./mm	Ω/km	Ω/km	Ω/km	Ω/km	Amps	Amps	Amps
1.	Mole	15	3/2.50	a) 2.2286 b) 2.3040	2.5896 2.6559	2.6699 2.7381	2.7902 2.8616	33 72	88 87	105 104
2.	Squirrel	20	7/2.00	a) 1.4969 b) 1.5410	1.7395 1.7912	1.7934 1.8467	1.8742 1.9370	92 90	110 109	132 130
3.	Weasel	34	7/2.50	a) 0.9580 b) 0.9900	1.1133 1.1418	1.1478 1.1772	1.1990 1.2302	121 119	146 144	175 173
4.	Rabbit	55	7/3.15	a) 0.6034 b) 0.6210	0.7013 0.7215	0.7230 0.7438	0.7556 0.7773	160 158	194 191	231 231
5.	Raccoon	80	7/3.81	a) 0.4125 b) 0.4250	0.4795 0.4942	0.4943 0.5095	0.5166 0.5325	202 199	246 242	297 293
6.	Dog	100	7/4.26	a) 0.3299 b) 0.3390	0.3836 0.3945	0.3955 0.4067	0.4133 0.4250	232 229	283 272	343 338
7.	Dog(up)	125	19/2.89	a) 0.2654 b) 0.2735	0.3087 0.3181	0.3182 0.3279	0.3325 0.3427	266 262	325 320	398 389
8.	Dog(up)/Coyote	150	19/3.15	a) 0.2234 b) 0.2290	0.2599 0.2674	0.2680 0.2756	0.2800 0.2880	395 291	362 357	440 434
9.	Wolf	175	19/3.40	a) 0.1918 b) 0.1969	0.2232 0.2293	0.2301 0.2363	0.2404 0.2470	324 320	398 393	485 478
10.	Wolf(up)	200	19/3.66	a) 0.1655 b) 0.1710	0.1927 0.1988	0.1987 0.2049	0.2076 0.2141	354 349	436 430	532 524
11.	Panther	232	19/3.94	a) 0.1428 b) 0.1471	0.1664 0.1714	0.1716 0.1767	0.1792 0.1846	387 382	478 471	584 575
12.	Panther (up)	290	37/3.15	a) 0.1150 b) 0.1182	0.1340 0.1380	0.1380 0.1423	0.1445 0.1486	442 436	548 540	661 661
13.	Panther (up)	345	37/3.45	a) 0.0958 b) 0.0984	0.1121 0.1151	0.1155 0.1186	0.1209 0.1239	493 487	613 605	752 742
14.	Kundah	400	37/3.71	a) 0.08289 b) 0.08550	0.09717 0.10015	0.10013 0.10320	0.10457 0.10779	538 530	670 660	824 811
15.	Zebra	465	37/4.00	a) 0.07130 b) 0.07340	0.08883 0.08627	0.08637 0.08888	0.09018 0.09281	589 580	736 725	905 892
16.	Zebra (up)	525	61/3.31	a) 0.06330 b) 0.06510	0.07466 0.07668	0.07691 0.07899	0.08028 0.08246	632 623	792 781	976 963
17.	Moose	570	61/3.45	a) 0.05827 b) 0.05980	0.06891 0.07070	0.07097 0.07282	0.07407 0.07601	663 655	833 822	1028 1015
18.	Morkulla	605	61/3.55	a) 0.05503 b) 0.05800	0.06521 0.06724	0.06716 0.06925	0.07008 0.07227	686 676	862 849	1065 1049
19.	Moose (up)	640	61/3.66	a) 0.05177 b) 0.05340	0.06150 0.06337	0.06332 0.06525	0.06607 0.06808	711 700	894 881	1106 1089
20.	Morkulla (up)	695	61/3.81	a) 0.04778 b) 0.04920	0.05697 0.05864	0.05865 0.06037	0.06117 0.06297	745 734	939 925	1162 1145
21.	Bersimis	765	61/4.00	a) 0.04335 b) 0.04460	0.05196 0.05341	0.05348 0.05497	0.05576 0.05732	788 777	995 981	1234 1217

Note:
Resistance
(a) At resistivity 0.0325 Ω·mm²/mm and nominal diameter of wires
(b) At resistivity 0.0325 Ω·mm²/mm and minimum diameter of wires

ALL ALUMINIUM ALLOY CONDUCTORS (AAAC) REC Spn-No. 33/1984 (R-1991)

Distribution Conductors to REC Standards

AAAC Size to Size equivalent to ACSR Code	Nominal Alu-Area	Stranding and wire diameter	Sectional Area	Approx. Overall Diameter	Approx. Mass	Calculated Resistance at 20°C (Maximum)	Approx. Calculated Breaking Load
	mm^2	mm	mm^2	mm	kg/km	Ω/km	kN
Mole	14	3/2.50	14.73	5.38	40.13	2.304	4.331
Squirrel	20	7/2.00	21.99	6.00	60.13	1.541	6.467
Weasel	30	7/2.50	34.36	7.50	94.00	0.990	10.106
Rabbit	50	7/3.15	54.55	9.45	149.20	0.621	16.044
Raccoon	80	7/3.81	79.81	11.43	218.26	0.425	23.473
Dog	100	7/4.26	99.77	12.78	272.86	0.339	29.344

ALUMINIUM ALLOY WIRES USED IN THE CONSTRUCTION OF STRANDED ALUMINIUM ALLOY CONDUCTORS
As per IS – 398 Part IV/1994

AAAC			Cross Sectional Area of Nominal Diameter of Wire	Mass	Minimum Breaking Load		Resistance at 20°C Maximum
Nom.	Min.	Max.			Before Stranding	After Stranding	
mm	mm	mm	mm^2	kg/km	kN	kN	Ω/km
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
2.00	1.98	2.02	3.142	8.482	0.97	0.92	10.653
2.50	2.47	2.53	4.909	13.25	1.52	1.44	6.845
2.89	2.86	2.92	6.560	17.71	2.03	1.93	5.106
3.15	3.12	3.18	7.793	21.04	2.41	2.29	4.290
3.31	3.28	3.34	8.605	23.23	2.66	2.53	3.882
3.40	3.37	3.43	9.079	24.51	2.80	2.66	3.677
3.45	3.42	3.48	9.348	25.24	2.89	2.75	3.571
3.55	3.51	3.59	9.998	26.72	3.60	2.91	3.390
3.66	3.62	3.70	10.52	26.41	3.25	3.09	3.187
3.71	3.67	3.75	10.81	21.19	3.34	3.17	3.101
3.81	3.77	3.85	11.40	30.78	3.52	3.34	2.938
3.94	3.90	3.98	12.19	32.92	3.77	3.58	2.746
4.00	3.96	4.04	12.57	33.93	3.88	3.69	2.663
4.26	4.22	4.30	14.25	38.48	4.40	4.18	2.345

ALUMINIUM CONDUCTORS STEEL REINFORCED (ACSR) Sizes to IS 398 (Part II) / 1976

Mechanical Parameters

Sr. No.	ACSR Code	Nom. Alum Area	Stranding and Wire Diameter (Alm + Steel)	Sectional Area		Approximate		Rated Strength		Span	Tension				Sag		
				Alum	Total	OD	Mass				32°C	0°C			53°C	75°C	90°C
		sq m	Nos./mm	sq mm	sq mm	mm	kg/km	kN	Kgf	m	Kgf	Kgf	Kgf	Kgf	m	m	m
												Wind pressure kg/sq. m 50	75	100			
1	Mole	10	6+1/1.50	10.60	12.37	4.50	43	3.97	405	67	101	174	187	201	NA	0.62	NA
2	Squirrel	20	6+1/2.11	20.98	24.48	6.33	&	7.61	776	67	194	325	341	370	NA	0.65	NA
										107	194	339	360	404	NA	131	NA
3	Weasel	30	6+1/2.59	31.61	36.88	7.77	128	11.12	1134	67	284	475	493	514	NA	0.67	NA
										107	284	487	523	564	NA	1.34	NA
4	Rabbit	50	6+1/3.35	52.88	61.70	10.05	214	18.25	1861	67	465	774	793	818	NA	0.68	NA
										107	465	780	823	873	NA	137	NA
										125	465	784	838	899	NA	1.73	NA
5	Raccoon	80	6+1/4.09	78.83	91.97	12.27	319	26.91	2744	125	686	1135	1196	1267	NA	1.74	NA
6	Dog	100	6/4.72 +7/1.57	105.00	118.50	14.15	394	32.41	3305	125	826	1389	1457	1537	NA	1.81	NA
												Wind pressure kg/sq. m 43	25	52			
7	Leopard	130	6/5.28	131.40	148.20	15.81	492	40.70	4150	240	1034	1612	1625	1672	4.16	4.92	NA
			+7/1.75							260	1034	1597	1611	1664	4.80	5.60	NA
8	Coyote	130	26/2.54	131.70	15220	15.89	522	46.40	4739	260	1183	1782	1795	1845	4.47	5.25	NA
			+7/1.91							275	1183	1771	1786	1839	4.94	5.75	NA
9	Wolf	150	30+7/2.5	158.10	194.90	18.13	726	67.34	6867	260	1717	2428	2441	2489	4.24	4.95	NA
										275	1717	2413	2427	2479	4.69	5.44	NA
10	Lynx	180	30+7/2.79	183.40	226.20	19.53	844	77.96	7950	300	1998	2739	2755	2815	5.52	6.31	NA
11	Panther	200	30+7/3.00	212.10	261.50	21.00	974	89.67	9144	320	2286	3095	3113	3180	6.24	7.06	NA
12	Goat	320	30+7/3.71	32430	400.00	25.97	1488	137.00	13975	320	3494	4628	4647	4719	6.24	7.05	NA
										350	3494	4555	4576	4656	7.36	8.22	NA
13	Drake	400	26/4.44	402.60	468.00	28.11	1628	139.00	14175	350	3544	4679	4703	4794	7.93	am	NA
			+7/1.96							380	2264	3021	3049	3156	1120	12.17	NA
14	Kundah	400	4W3.5	404.10	425.20	26.88	1281	88.80	9054	350	2264	3082	3110	3212	9.62	10.57	NA
			+7/1.96							380	2264	3021	3049	3156	11.20	12.17	NA
15	Zebra	420	54+7/3.18	428.90	484.50	28.62	1621	130.30	13289	350	3322	4338	4362	4454	8.35	9.24	NA
										380	3322	4265	4292	4390	9.72	10.65	NA
16	Deer	420	30+7/4.27	429.60	529.80	29.89	1979	178.40	18190	350	4548	5841	4863	5863	8.73	9.63	NA
										380	4548	5748	5772	5863	8.73	9.63	NA
17	Moose	520	54+7/3.53	528.50	597.00	31.77	1998	159.60	16275	380	4069	5155	5182	5283	9.78	10.70	NA
										400	4069	5101	5129	5234	10.76	11.70	NA
18	Morkulla	560	42/4.13	562.70	591.70	31.68	1781	120.20	12253	380	3063	3947	3977	4089	11.37	12.43	NA
			+7/2.30							400	3063	3899	3929	4044	12.52	13.59	NA
19	Bersimis	690	42/4.57 +7/2.54	688.90	724.40	35.04	2187	146.90	14977	400	3744	4686	4717	4834	12.66	13.64	NA

Rate: EDT = 25% of Rated Strength

ALUMINIUM CONDUCTORS STEEL REINFORCED (ACSR) Sizes to IS 398 (Part II) / 1976

Electrical Parameters

Sr. No.	ACSR Code	Nom. Alum Area	Stranding and Wire Diameter Alm. + Steel	DC Resistance at 20°C	AC Resistance at in Ω/km			Current Capacity in amperes		
					65°C	75°C	90°C	65°C	75°C	90°C
		sq mm	Nos./ mm	Ω/km	Ω/km	Ω/km	Ω/km	amps	amps	amps
1.	Mole	10	6+1/1.50	2.78	3.777	3.905	NA	58	70	NA
2.	Squirrel	20	6+1/2.11	1.394	1.894	1.958	NA	89	107	NA
3.	Weasel	30	6+1/2.59	0.9291	1.262	1.305	NA	114	138	NA
4.	Rabbit	50	6+1/335	0.5524	0.7506	0,7761	NA	157	190	NA
5.	Raccoon	80	6+1/4.09	0.3712	0.5044	0.5216	NP	200	244	NA
6.	Dog	100	6/4.72 +7/1.57	0.2792	0.3794	0.3924	NA	239	291	NA
7.	Leopard	130	6/528 +7/1.75	0.2226	0.3026	0.3129	NA	274	335	NA
8.	Coyote	130	26/2.54 +7/1.91	0.2246	0.2663	0.2754	NA	292	358	NA
9.	Wolf	150	30+7/2.59	0.1871	0.2219	0.2295	NA	329	405	NA
10.	Lynx	180	30+7/2.79	0.161	0.1909	0.1974	NA	361	445	NA
11.	Panther	200	30+7/3.00	0.139	0.165	0.1706	NA	395	487	NA
12.	Goat	320	30+7/3.71	0.09106	0.1082	0.1119	NA	510	634	NA
13.	Drake	400	26/4.44 +3.45	0.07309	0.08709	0.03002	NA	578	721	NA
14.	Kundan	400	42/3.5 +7/1.96	0.07269	0.08917	0.09217	NA	566	705	NA
15.	Zebra	420	54+7/3.18	0.06869	0.08416	0.08699	NA	590	737	NA
16.	Deer	420	30+7/4.27	0.06854	0.08164	0.0844	NA	605	756	NA
17.	Moose	520	54+7/3.53	0.05596	0.06881	0.07111	NA	667	836	NA
18.	Morkulla	560	42/4.13 +7/2.30	0.05232	0.06467	0.06681	NA	688	862	NA
19.	Bersimis	690	42/4.57 +7/2.54	0.04242	0.05092	0.0524	NA	791	998	NA

Note: Current Capacity at a = 05, e = 0.5, s = 985, v = 2200
Ambient Temperature 40°C at sea level

ALL ALUMINIUM CONDUCTORS (TO IS 398)

No. And Diameter of wires	Nominal Copper Area	Calculated Eq: area of Aluminium	Approx. Overall diameter	Approx. Wt.	Resistance At 20 °C	Ultimate Strength of Condr.
mm	mm^2	mm^2	mm	Kg./Km	Ω/Km	kg.
7/1.50	7.5	12.23	4.50	34	2.32600	220
7/1.96	13.0	20.89	5.88	58	1.36200	385
7/2.21	16.0	26.56	6.63	73	1.07100	485
7/2.44	20.0	32.37	7.32	89	0.87870	580
7/2.79	25.0	42.33	8.37	117	0.67210	737
7/3.10	30.0	52.26	9.30	144	0.54440	892
7/3.40	40.0	62.86	10.20	174	0.45260	1051
7/3.66	45.0	72.84	1 0.95	201	0.39060	1203
7/3.78	48.0	77.70	11.34	215	0.36620	1272
7/3.91	50.0	83.13	11.73	230	0.34220	1356
7/4.17	60.0	94.56	12.51	261	0.30090	1523
7/4.39	65.0	104.80	13.17	290	0.27150	1673
19/3.00	80.0	132.20	15.00	369	0.21520	2228
19/3.18	90.0	148.50	15.90	414	0.19160	2484
19/3.53	110.0	183.00	17.65	511	0.15550	2985
19/3.78	130.0	209.90	18.90	586	0.13560	3381
19/3.99	140.0	233.80	19.95	652	0.12170	3736
19/4.22	160.0	261.50	21.10	730	0.10880	4144
19/4.65	185.0	317.50	23.25	886	0.08959	4947
19/5.00	225.0	367.20	25.00	1025	0.07749	5695
19/5.36	260.0	421.90	26.80	1176	0.06743	6516
37/4.09	300.0	473.60	28.63	1343	0.05982	7289
37/4.27	325.0	518.50	29.89	1464	0.05488	7878

STRANDED STEEL-CORED ALUMINIUM CONDUCTORS (TO IS: 398)

No. and Diameter of wires		Nominal Copper Area mm²	Calculated Eq: area of Alu. mm²	Approx. overall diameter mm	Approx. Wt. in Kg ./Km			Resistance at 20 °C Cl /Km	Ultimate strength Kg.
Alu. mm.	Steel mm.				Alu. Kg.	Steel Kg.	Complete conductor Kg.		
6/1.50	1/1.50	6.5	10.47	4.50	29.0	14.0	43	2.71800	407
6/2.11	1/2.11	13	20.71	6.33	58	27	85	1.37400	771
6/2.36	1/2.36	16	25.11	7.08	72	34	106	1.09800	952
6/2.59	1/2.59	20	31.21	7.77	87	41	128	0.91160	1137
6/3.00	1/3.00	25	41.87	9.00	116	55.0	171	0.67950	1503
6/3.35	1/3.35	30	52.2	i 0.05	145.0	69.0	214	0.54490	1860
6/3.66	1/3.66	40	62.32	10.98	173	82	255	0.45650	2207
12/2.79	7/2.79	42	71.58	13.95	199	334	533	0.39770	6108
6/3.99	1/3.99	45	74.07	11.97	203	98	301	0.38410	2613
6/4,09	1/4.09	48	77.83	12.27	215	104	319	0.36560	2746
6/4.22	1/4.22	50	82.85	12.66	227	109	336	0.34340	2983
6/4.50	1/4.50	55	94.21	13.50	258	124.0	382	0.30200	3324
6/4.72	7/1.57	65	103.60	14.16	287	107	394	0.27450	3299
6/5.28	7/1.76	80	129.70	15.81	356	136	492	0.21930	4137
26/2,54	7/1.90	80	128.50	15.89	357	165	522	0.22140	4638
30/2.36	7/2.36	80	128.10	16.52	363.5	240.5	604	0.22210	5758
30/2.59	7/2.59	95	154.30	18.13	428	298	726	0.18440	6880
30/2.79	7/2.79	110	179.00	19.53	497	347	844	0.15890	7950
30/3.00	7/3.00	130	207.00	21.00	587	387	974	0.13750	9127
30/3.18	7/3.18	140	232.50	22.26	657	443	1100	0.12230	10210
30/3.35	7/3.35	160	258.10	23.45	651	492	1143	0.11020	11310
30/3.71	7/3.71	185	316.50	25.97	878	610	1488	0.08989	13780
30/3.99	7/3.99	225	366.10	27.93	1035	691	1726	0.07771	15910
42/3.50	7/1.96	250	394.40	26.82	1114	168	1282	0.07434	9002
30/4.27	7/4.27	260	419.30	29.89	1163	816	1979	0.06786	18230
30/4.50	7/4.50	300	465.70	31.50	1317	887	2196	0.06110	20240
54/3.35	7/3.55	300	464.50	30.15	1314	492	1804	0.06125	14750
54/3 535	7/3.53	325	515.70	31.77	1466	536	2002	0.05517	16250

ALUMINIUM WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS, GALVANIZED STEEL-REINFORCED

(Clauses 6.1, 8.1.1, 13.2, 13.3.1, 13.5.1 and 13.6) (IS: Part II 1996)

Diameter			Cross Sectional Area of Nominal Diameter	Mass	Resistance at 20°C	Breaking Load	
Nominal	Min	Max				Before Stranding	After Stranding
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
mm	mm	mm	mm^2	kg/km	ohm/km	kN	kN
1.50	1.48	1.52	1.767	4.78	16.432	0.32	0.30
1.96	1.94	1.98	3.017	8.16	9.561	0.54	0.51
2.11	2.09	2.13	3.497	9.45	8.237	0.63	0.60
2.59	2.56	2.62	5.269	14.24	5.490	0.89	0.85
3.00	2.97	3.03	7.069	19.11	4.079	1.17	1.11
3.18	3.15	3.21	7.942	21.47	3.626	1.29	1.23
3.35	3.32	3.38	8.814	23.82	3.265	1.43	1.36
3.50	3.46	3.54	9.621	26.01	3.006	1.55	1.47
3.53	3.49	3.57	9.787	26.45	2.954	1.57	1.49
3.80	3.76	3.84	11.34	30.65	2.545	1.80	1.71
4.09	4.05	4.13	13.14	35.51	2.194	2.08	1.98
4.13	4.09	4.17	13.40	36.21	2.151	2.13	2.02
4.72	4.67	4.77	17.50	47.30	1.650	2.78	2.64

Note: The resistance has been calculated from the maximum value of resistivity and the cross-section based on the minimum diameter.

STEEL WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS

Diameter			Cross Sectional Area of Nominal Diameter	Mass	Breaking Load (Min)	
Nominal	Min	Max			Before Stranding	After Stranding
1	2	3	4	5	6	7
mm	mm	mm	mm^2	kg/km	kN	kN
1.50	1.47	1.53	1.767	13.78	2.46	2.34
1.57	1.54	1.60	1.936	15.10	2.70	2.57
1.96	1.92	2.00	3.017	23.53	4.20	3.99
2.11	2.07	2.15	3.497	27.27	4.60	4.37
2.30	2.25	2.35	4.155	32.41	5.46	5.19
2.59	2.54	2.64	5.269	41.09	6.92	6.57
3.00	2.94	3.06	7.069	55.13	9.29	8.83
3.18	3.12	3.24	7.942	61.95	10.43	9.91
3.35	3.28	3.42	8.814	68.75	11.58	11.00
3.53	3.46	3.60	9.787	76.34	12.86	12.22
4.09	4.01	4.17	13.14	102.48	17.27	16.41

ALUMINIUM CONDUCTORS, GALVANIZED STEEL - REINFORCED

(IS 398 (Part - 2) 1996)

Nominal Aluminium	Stranding and Wire Diameter		Sectional Area of Aluminium	Total Sectional Area	Approximate Diameter	Approximate Mass	Calculated Resistance at 20°C (Max)	Approximate Calculated Breaking Load.
	Aluminium	Steel						
1	2	3	4	5	6	(7)	8	9
mm	mm	mm	mm^2	kg/km	ohm/km	kN	kN	kN
10	6/1.50	1/1.50	10.60	12.37	4.50	43	2.780	3.97
18	6/1.96	1/1.96	18.10	21.12	5.88	73	1.618	6.74
20	6/2.11	1/2.11	20.98	24.48	6.33	85	1.394	7.61
30	6/2.59	1/2.59	31.61	36.88	7.77	128	0.9289	11.12
50	6/3.35	1/3.35	52.88	61.70	10.05	214	0.5524	18.25
80	6/4.09	1/4.09	78.83	91.97	12.27	319	0.3712	26.91
100	6/4.72	1/4.72	105.0	118.5	14.15	394	0.2792	32.41
100	6/4.72	7/1.57	105.0	118.5	14.15	394	0.2792	32.41
150	30/2.59	7/2.59	158.1	194.9	18.13	726	0.1871	67.34
200	30/3.00	7/3.00	212.1	261.5	21.00	974	0.1390	89.67
400	42/3.50	7/1.96	404.1	425.2	26.88	1281	0.07311	88.79
420	54/3.18	7/3.18	428.9	484.5	28.62	1621	0.06868	130.32
520	54/3.53	7/3.53	528.5	597.0	31.77	1998	0.05595	159.60
560	42/4.13	7/2.30	562.7	591.7	31.68	1781	0.05231	120.16

Note: For the basis at calculation in this table (see appendix A) The sectional area is the sum of the cross-sectional area of the relevant individual wires.

TABLE 4. LAY RATIO OF ALUMINIUM CONDUCTORS , GALVANIZED STEEL-REINFORCED

1	2	3	4	5	6	7	8	9	10	11
Number of wires		Rate of Alu. Wire Diameter to Steel Wire Diameter	Lay Ratio for Steel Core (6 wire Layer)		Lay Ratios for Aluminium Wire					
Alu	Steel				Outermost Layer		Layer Immediately Beneath Outermost Layer		Innermost Layer of Conductors with 3 ALU. Wire Layer	
			Min	Max	Min	Max	Min	Max	Min	Max
6	1	1.0	-	-	10	14	-	-	-	-
6	7	3.0	13	28	10	14	-	-	-	-
30	7	1.0	13	28	10	14	10	16	-	-
42	7	1.8	13	28	10	14	10	16	10	17
54	7	1.0	13	28	10	14	10	16	10	17

Note: For the purpose of calculation, the mean lay ratio shall be taken as the arithmetic mewl of the relevant minimum and maximum values given in this table.

Standing Constants

Number of wires in conductor		Mass		Stranding Constant Electrical Resistance
Aluminium	Steel	Aluminium	Steel	
1	2	3	4	5
6	1	6.091	1.000	0.169 2
6	7	6.091	7.032	0.169 2
30	7	30.67	7.032	0.034 08
42	7	42.90	7.032	0.024 32
54	7	55.23	7.032	0.018 94

MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

Number of wires		Final Modulus of Elasticity (Practical) GN/m^2	Coefficient of Linear Expansion /°C
Aluminium	Steel		
1	2	3	4
6	1	79	19.1X 10^{-6}
6	7	75	19.8X 10^{-6}
30	7	80	17.8X10^{-6}
42	7	62	21.5X10^{-6}
54	7	69	19.3X10^{-6}

Note:

1. These values are given for information only.
2. Moduli values quoted may be regarded as being accurate to within ± GN/m'.
3. Moduli values quoted may be taken as applying to conductors stressed between 15 and 50 percent of the ultimate strength of the conductor.
4. Coefficients of linear expansions have been calculated from the final (Practical) moduli for the aluminium and steel components of the conductors and coefficients of linear expansion of 23.0 X 10^{-6} and 11.5 X 10^{-6} °C for aluminium and steel respectively.

WEIGHT OF ALUMINIUM, STEEL AND TOTAL WEIGHT IN KG/KM FOR ACSR CONFIRMING TO IS 398(P-II)11996

Sr. No	Code Name	Nominal Mu. area	Size Nos./imm	Approximate Weight in kg/km		
				Aluminium	Steel	(Complete conductor) Total
1	Mole	10	6+1/1.50	29.0	14.0	43.0
2	Squirrel	18	6+1/1.96	49.5	23.5	73.0
3	Squirrel	20	6+1/2.11	58	27	85
4	Gopher*	16	6+1/2.36	72	34	106
5	Weasel	30	6+1/2.59	87	41	128
6	Fox*	23	6+1/2.79	100	48	148
7	Ferrel*	25	6+1/3.00	116	55	171
8	Rabbit	50	6+1/3.35	145	69	214
9	Raccoon	80	6+1/4.09	215	104	319
10	Mink*	40	6+1/3.66	173	82	255
11	Horse*	42	12+7/2.79	199	334	533
12	Bever*	45	6+1/3.99	203	98	301
13	Otter*	50	6+1/4.22	227	109	336
14	Cat*	55	6+1/4.50	258	124	382
15	Dog	100	6/4.72+7/1.57	287	107	394
16	Leopard*	130	6/5.28+7/1.75	356	136	492
17	Coyote*	130	26/2.54+7/1.97	357	165	522
18	Wolf	150	30+7/2.59	428	298	726
19	LYRX*	180	30+7/2.79	497	347	844
20	Panther	200	30+7/3.00	587	387	974
21	Goat*	320	30+7/3.71	878	610	1488
22	Drake	400	26/4.44+7/3.45	1087	541	1628
23	Kundah	400	42/3.5+47/1.96	1114	168	1282
24	Zebra	420	54+7/3.18	1186	435	1621
25	Deer*	420	30+7/4.27	1163	816	1979
26	Moose	520	54+7/3.53	1466	536	2002
27	Morkulla	560	42/4.13+7/2.30	1523	258	1781
28	Bersimis	690	42/4.57+7/2.54	1903	284	2187
29	Bear*	250	30/3.35+7/3.35	651	497	1143
30	Lion*	230	30/3.18+7/3.18	667	443	1100
31	Sheep*	350	30/3.99+7/3.99	1035	691	1726
32	EK*	469	30/4.69+7,14.60	1317	887	2204
33	Camel*	450	54/3.35+7/3.35	1314	492	1806

Note: Code name and sized marked *, though not appearing in IS in particular, these ranges can be supplied confirming to IS 398(P-II)/1996

IS: 398-Part 1/1978 (ALUMINIUM STRANDED CONDUCTOR)

1. Spools offered for inspection shall be divided into equal lots, the number of lots being equal to the number of samples to be selected, a fraction of a lot being counted as a complete lot. One sample spool shall be selected at random from each lot.
2. **Breaking Load Test -** The breaking load of one specimen cut from each of the sample taken shall be determined by means of a suitable tensile testing machine. The load shall be applied gradually and the rate of separation of the jaws of the testing machine shall be not less than 25 mm/min and not greater than 100 mm/min.

   The ultimate breaking load of the specimen shall be not less than the appropriate value specified in Table 1.
3. **Wrapping Test -** One specimen cut from each of the samples taken shall be wrapped round a mandrel of diameter equal to the wire diameter to form a close helix of 8 turns. Six turns shall then be unwrapped and again closely wrapped in the same direction as before. The wire shall not break or show any crack.
4. **Resistance Test -** The electrical resistance of one specimen cut from each of the samples taken shall be measured at ambient temperature. The measured resistance shall be corrected to the value at 20°C by means of the formula:

$$R_{20} = RT \frac{1}{1 + \alpha (T - 20)}$$

Where

R_{20} = resitance corrected at 20°C.

R_T = resitance measured at T°C.

a = constant - mass temperature coefficient of resistance, 0.004, and

T = ambient temperature during measurement.

The resistance corrected at 20°C shall be not more than the maximum value specified in Table 1.

12. REJECTION AND RETEST

12.1 Should any specimen not fulfil any of the test requirements, the particular coil from which the sample was taken shall be withdrawn. In respect of each failure, two specimen shall be selected from two different coils in the lot and subjected to the test in which failure occurred. If either of the two specimen fails to pass that test, the lot shall be rejected.

12.2 If any selected coil fails after retest, the manufacturer may test each coil and submit those for further inspection.

TABLE-1: ALUMINIUM WIRES USED IN THE CONSTRUCTION OF ALUMINIUM STRANDED CONDUCTORS

(Clauses 4.1, 6.1.1, 6.1.2, 11.2 and 11.4) (IS: 398-Part1/1976)

Diameter			Cross Sectional Area of Nominal Diameter Wire	Mass	Resistance at 20° C, Maximum	Breaking Load Minimum	
Nom	Min	Max				Before Standing	After Standing
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
mm	mm	mm	mm2	kg/km	f2 /km	kN	kN
2.21	2.19	2.23	3.836	10.37	7.553	0.68	0.65
3.10	3.07	3.13	7.548	20.40	3.843	1.24	1.18
3.18	3.15	3.21	7.942	21.47	3.651	1.29	1.23
3.99	3.95	4.03	12.50	33.80	2.322	1.98	1.88
4.39	4.35	4.43	15.14	40.91	1.194	2.40	2.28
4.65	4.60	4.70	16.98	45.90	1.712	2.70	2.56

Note:

1. The resistance has been calculated from the maximum values of resistivity and the cross-sectional area based on the minimum diameter.
2. The resistance of that individual wires shall be such that the completed standard conductor meets the requirements of the maximum resistance specified in the Table 2 calculated by applying the relevant stranding constants given in Table 4.

TABLE 2 ALUMINIUM STRANDED CONDUCTORS

Clauses 6.2.1, 6.2.2, and Table 1 (Note 2) (IS: 398-Part 1/1976)

Nominal Aluminium Area	Stranding and Wire Diameter	Sectional Area	Approximate Overall Diameter	Approximate Mass	Calculated Resistance at 20°C, Max	Approximate Calculated Breaking Load
mm²	mm	mm²	mm	kg/km	Ω/km	kN
25	7/2.21	26.85	6.63	74	1.093	4.52
50	7/3.10	52.83	9.30	145	0.556 1	8.25
100	7/4.39	106.0	13.17	290	0.277 0	15.96
150	19/3.18	150.9	15.90	415	0.195 6	23.28
240	19/3.99	237.6	19.95	654	0.124 4	35.74
300	19/4.65	322.7	23.25	888	0.091 71	48.74

Note:

1. For the basis of calculation of this table, see appendix A
2. The Sectional area of a stranded conductor has been taken as the sum of the cross sectional areas of the individual wires.

TABLE 3 LAY RATIOS FOR ALUMINIUM STRANDED CONDUCTORS

(Clauses 8.2 and A-2-3) (IS: 398 - Part 1 / 1976)

Number of Wires in Conductor	Lay Ratio			
	6 Wire Layer		12 Wire Layer	
	Min	Max	Min	Max
1	2	3	4	5
7	10	14	-	-
19	10	16	10	14

NOTES ON THE CALCULATION OF TABLE 2

A-1 INCREASE IN LENGTH DUE TO STRANDING

A-1.1 When straightned out, each wire in any particular layer of a stranded conductor, except the central wire, is longer than the stranded conductor by an amount depending on the lay ratio of that year.

A-2 RESISTANCE AND MASS OF CONDUCTOR

A-2.1 The resistance of any length of a standard conductor is the resistance of the same length of any one wire multiplied by a constant, as set out in Table 4.

A-2.2 The mass of each wire in any particular layer of stranded conductor, except the central wire, will be greater than that of an equal length of straight wire by an amount depending on the lay ratio of that layer (see A-1.1 above). The total mass of any length of an aluminum stranded conductor is, therefore obtained by multiplying the mass of an equal length of straight wire by an appropriate constant, as set out in Table 4.

A-2.3 In calculating the stranding constants in Table 4, the mean lay ratio, that is the arithmetic mean of the relevant minimum and maximum values in Table 3, has been assumed for each layer.

A-3 CALCULATED BREAKING LOAD OF CONDUCTOR

A-3.1 The breaking load of an aluminum stranded conductor containing not more than 37 wires, in terms of the strengths of the individual component wires, may be taken to be 95 percent of the sum of the strengths of the individual aluminium wires calculated from the specified minimum tensile strength.

TABLE 4: STRANDING CONSTANTS

(Clauses A-2.1, A-2.2, A-2.3 and Table 1 (Note 2))

Number of Wires In Conductor	Stranding Constants	
	Mass	Electrical Resistance
1	2	3
7	7.091	0.144 7
19	19.34	0.053 57

MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

(Clause 0.5) (IS: 398 - Part 1 / 1976)

No. of Wires	Final Modulus of Elasticity (Practical) GN/m²	Coefficient of Linear Expansion/°C
7	59	23.0×10^{-6}
19	60	23.0×10^{-6}

Note:

1. These values are given for information only.
2. Moduli values quoted may be regarded as being accurate to within 3 GN/m².
3. Moduli values quoted may be taken as applying to conductors stressed between 15 and 50 percent of the ultimate strength of the conductor.

TABLE 1 ALUMINIUM WIRES USED IN THE CONSTRUCTION OF ALUMINIUM STRANDED CONDUCTORS

(Clauses 4.1, 6.1.1, 6.1.2, 11.2 and 11.4) (Clause 0.5) (IS: 398 - Part 1 / 1976 - Amendment 2 / July '93)

Diameter			Cross Sectional Area of Nominal Diameter Wire	Mass	Resistance at 20° C, Maximum	Breaking Load Minimum	
Nom	Minimum	Maximum				Before Standing	After Standing
mm	mm	mm	mm²	kg/km	Ω/km	kN	kN
2.21	2.19	2.23	3.836	10.37	7.503	0.68	0.65
3.10	3.07	3.13	7.548	20.40	3.818	1.24	1.18
3.18	3.15	3.21	7.942	21.47	3.626	1.29	1.23
3.99	3.95	4.03	12.50	33.80	2.306	1.98	1.88
4.39	4.35	4.43	15.14	40.91	1.902	2.40	2.28
4.65	4.60	4.70	16.98	45.90	1.700	2.70	2.56

Note:

1. The resistance has been calculated from the maximum values of resistivity and the cross-sectional area based on the minimum diameter.
2. The resistance of that individual wires shall be such that the completed standard conductor meets the requirements of the maximum resistance specified in the table 2 calculated by applying the relevant stranding constants given in table 4.

TABLE 2 ALUMINIUM STRANDED CONDUCTORS

Clauses 6.2.1, 6.2.2, and Table 1 (Note 2) (IS: 398 - Part 1 / 1976 - Amendment 2 / July '93)

Nominal Aluminium Area	Stranding and Wire Diameter	Sectional Area	Approximate Overall Diameter	Approximate Mass	Calculated Resistance at 20°C, Max	Approximate Calculated Breaking Load
mm²	mm	mm²	mm	kg/km	Ω/km	kN
25	7/2.21	26.85	6.63	74	1.086	4.52
50	7/3.10	52.83	9.30	145	0.552 5	8.25
100	7/4.39	106.0	13.17	290	0.275 2	15.96
150	19/3.18	150.9	15.90	415	0.194 2	23.28
240	19/3.99	237.6	19.95	654	0.123 5	35.74
300	19/4.65	322.7	23.25	888	0.091 07	48.74

Note:

1. For the basis of calculation of this table, see appendix A.
2. The Sectional area of a stranded conductor has been taken as the sum of the cross sectional areas of the individual wires.

ALUMINIUM WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS. GALVANIZED STEEL-REINFORCED

IS: 398 (part II) 1996

Diameter			Cross Sectional Area of Nominal Diameter Wire	Mass	Resistance at 20° C	Breaking Load	
Nom	Minimum	Maximum				Before Standing	After Standing
mm	mm	mm	mm²	kg/km	Ω/km	kN	kN
1.50	1.48	1.52	1.767	4.78	16.54	0.32	0.30
1.96	1.94	1.98	3.017	8.16	9.625	0.54	0.59
2.11	2.09	2.13	3.497	9.45	8.293	0.63	0.60
2.59	2.56	2.62	5.269	14.24	5.527	0.89	0.85
3.00	2.97	3.03	7.069	19.11	4.107	1.17	1.11
3.18	3.15	3.21	7.942	21.47	3.651	1.29	1.23
3.35	3.32	3.38	8.814	23.82	3.286	1.43	1.36
3.50	3.46	3.54	9.621	26.01	3.026	1.55	1.47
3.53	3.49	3.57	9.787	26.45	2.974	1.57	1.49
3.80	3.76	3.84	11.34	30.65	2.562	1.80	1.71
4.09	4.05	4.13	13.14	35.51	2.208	2.08	1.98
4.13	4.09	4.17	13.40	36.21	2.165	2.13	2.02
4.72	4.64	4.77	17.50	47.30	1.661	2.78	2.64

Note:

1. The resistance has been calculated from the maximum value of resistivity and the cross sectional area based on the minimum diameter.
2. The resistance of the individual wire shall be such that the completed stranded conductor meets the requirements of the maximum resistance specified in Table 3 calculated by applying the relevant standing constants given in table 5.

STEEL WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS GALVANIZED STEEL-REINFORCED

IS: 398 (Part II) 1996

Diameter			Cross Sectional Area of Nominal Diameter Wire	Breaking Load Minimum		
Nom	Min	Max		Resistance at 20° C	Before Standing	After Standing
mm	mm	mm	mm^2	kg/km	kN	kN
1.50	1.47	1.53	1.767	13.78	2.46	2.34
1.57	1.54	1.60	1.936	15.10	2.70	2.57
1.96	1.92	2.00	3.017	23.53	4.20	3.99
2.11	2.07	2.15	3.497	27.27	4.60	4.37
2.30	2.25	2.35	4.155	32.41	5.46	5.19
2.59	2.54	2.64	5.269	41.09	6.92	6.57
3.00	2.94	3.06	7.069	55.13	9.29	8.83
3.18	3.12	3.24	7.942	61.95	10.43	9.91
3.35	3.28	3.42	8.814	68.75	11.58	11.00
3.53	3.46	3.60	9.787	76.34	12.86	12.22
4.09	4.01	4.17	13.14	102.48	17.27	16.41

ALUMINIUM WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS. GALVANIZED STEEL-REINFORCED

IS: 398 (part II) 1996

Diameter			Cross Sectional Area of Nominal Diameter Wire	Mass	Resistance at 20°C, Maximum	Breaking Load Min	
Nom	Min	Max				Before Standing	After Standing
mm	mm	mm	mm^2	kg/km	Ω/km	kN	kN
1.50	1.48	1.52	1.767	4.78	16.432	0.32	0.30
1.96	1.94	1.98	3.017	8.16	9.561	0.54	0.59
2.11	2.09	2.13	3.497	9.45	8.237	0.63	0.60
2.59	2.56	2.62	5.269	14.24	5.490	0.89	0.85
3.00	2.97	3.03	7.069	19.11	4.079	1.17	1.11
3.18	3.15	3.21	7.942	21.47	3.626	1.29	1.23
3.35	3.32	3.38	8.814	23.82	3.265	1.43	1.36
3.50	3.46	3.54	9.621	26.01	3.006	1.55	1.47
3.53	3.49	3.57	9.787	26.45	2.954	1.57	1.49
3.80	3.76	3.84	11.34	0.65	2.545	1.80	1.71
4.09	4.05	4.13	13.14	35.51	2.194	2.08	1.98
4.13	4.09	4.17	13.40	36.21	2.151	2.13	2.02
4.72	4.64	4.77	17.50	47.30	1.650	2.78	2.64

Note:

1. The resistance has been calculated from the maximum value of resistivity and the cross sectional area based on the minimum diameter.

TABLE 2 STEEL WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS GALVANIZED STEEL - REINFORCED

IS: 398 (Part II) 1996

Diameter			Cross Sectional Area of Nominal Diameter Wire	Mass	Breaking Load Minimum	
Nom	Min	Max			Before Standing	After Standing
mm	mm	mm	mm^2	kg/km	kN	kN
1.50	1.47	1.53	1.767	13.78	2.46	2.34
1.57	1.54	1.60	1.936	15.10	2.70	2.57
1.96	1.92	2.00	3.017	23.53	4.20	3.99
2.11	2.07	2.15	3.497	27.27	4.60	4.37
2.30	2.25	2.35	4.155	32.41	5.46	5.19
2.59	2.54	2.64	5.269	41.09	6.92	6.57
3.00	2.94	3.06	7.069	55.13	9.29	8.83
3.18	3.12	3.24	7.942	61.95	10.43	9.91
3.35	3.28	3.42	8.814	68.75	11.58	11.00
3.53	3.46	3.60	9.787	76.34	12.86	12.22
4.09	4.01	4.17	13.14	102.48	17.27	16.41

NOTES ON CALCULATION OF RESISTANCE, MASS AND BREAKING LOAD

A-1 INCREASE IN LENGTH DUE TO STRANDING

A-1.1 When straightened out, each wire in any particular layer of standard conductor, except the central wire, is longer than the stranded conductor by an amount depending on the lay ratio of that layer.

A-2 RESISTANCE AND MASS OF CONDUCTOR

A-2.1 In aluminium conductors, steel reinforced the conductivity of the steel core is neglected and the resistance of the conductor is calculated with reference to the resistance of the aluminium wires only. The resistance of any length of any one aluminium wire multiplied by a constant, as set out in Table 5.

A-2.2 The mass of each wire in a length of stranded conductor, except the central wire, will be greater than that of an equal length of straight wire by an amount depending on the lay ratio of the layer (see A-1.1). The total mass of any length of conductor is therefore, obtained by multiplying the mass of an equal length of straight wire by the approximate constant set out in Table 5. The masses of the steel core and aluminium wires are calculated separately and added together.

A-2.3 In calculating the stranding constant in Table 5, the mean lay ratio, that is, the arithmetic mean of the relevant minimum and maximum values in Table 4. has been assumed for each layer.

A-3 CALCULATED BREAKING LOAD OF CONDUCTOR

A-3.1 The breaking load of an aluminium conductor galvanised steel, reinforced in terms of the sum of the strength of the individual component wires, may be taken to be as follows:

(a) 98 percent of the sum of the breaking loads of the aluminium wires plus 89 percent of the sum of the breaking loads of the galvanized steel wires, when taken from the stranded conductor and tested: or

(b) 98 percent of the sum of the breaking loads of the aluminium wires plus 85 percent of the sum of the breaking loads of the galvanised steel wires, based on the minimum breaking loads of the component wires before stranding, that is in the coil.

A-3.2 The values of approximate breaking load of conductors, given in Table 3 have been calculated in accordance with (b) above and on the basis of the minimum breaking loads of the component wires given in Table 1 and 2.

LAY RATIOS AND STRANDING CONSTANTS FOR NON STANDARD CONSTRUCTIONS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Number of wires in conductor		Ratio a1. wire diameter to steel wire diameter	Lay ratios for steel core				Lay ratios for Aluminium wires						Standing constants		
			6-wire layer		12-wire layer		Outside layer		Layer immediately beneath outside layer		Innermost layer of conductors with 3 Aluminium wire layers		Mass		Elect. Resistance
Alum	Steel		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Alum	Steel	
24	7	1.500	13	28	-	-	10	14	10	16	-	-	24.50	7.032	0.04253
26	7	1.286	13	28	-	-	10	14	10	16	-	-	26.56	7.032	0.03928
28	7	1.125	13	28	-	-	10	14	10	16	-	-	28.61	7.032	0.03649
30	19	1.666	13	28	12	24	10	14	10	16	-	-	30.67	19.15	0.03408
42	7	1.800	13	28	-	-	10	14	10	16	10	17	42.90	7.032	0.02432
45	7	1.500	13	28	-	-	10	14	10	16	10	17	45.96	7.032	0.02271
49	7	1.286	13	28	-	-	10	14	10	16	10	17	49.06	7.032	0.02129
54	19	1.666	13	28	12	24	10	14	10	16	10	17	55.23	19.15	0.01894

ALL ALUMINIUM CONDUCTOR GALVANIZED STEEL - REINFORCED

IS 398 Part 2/1996

Nominal Aluminium	Stranding and wire diameter		Sectional area of Aluminium	Total sectional area	Approx. Diameter	Approx. Mass	Resistance at 20°C Maximum	Breaking load Minimum
	Aluminium	Steel						
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
mm^2	mm	mm	mm^2	mm^2	mm	kg/km	Ω/km	kN
10	6/1.50	1/1.50	10.60	12.37	4.50	43	2.780	3.97
18	6/1.96	1/1.96	18.10	21.12	5.88	73	1.618	6.74
20	6/2.11	1/2.11	20.98	24.28	6.33	85	1.394	7.61
30	6/2.59	1/2.59	31.61	36.88	7.77	128	0.9289	11.12
50	6/3.35	1/3.35	52.88	61.70	10.05	214	0.5524	18.25
80	6/4.09	1/4.09	78.83	91.97	12.27	319	0.3712	26.91
100	6/4.72	7/1.57	105.0	118.5	14.15	394	0.2792	32.41
150	30/2.59	7/2.59	158.1	194.9	18.13	726	0.1871	67.34
200	30/3.00	7/3.00	212.1	261.5	21.00	974	0.1390	89.67
400	42/3.50	7/1.96	404.1	425.2	26.88	1281	0.07311	88.79
420	54/3.18	7/3.18	428.9	484.5	28.62	1621	0.06868	130.32
520	54/3.53	7/3.53	528.5	597.0	31.77	1998	0.05595	159.60
560	42/4.13	7/2.30	562.7	591.7	31.68	1781	0.05231	120.16

CHEMICAL COMPOSITION OF HIGH CARBON STEEL

C-1 The chemical composition of high carbon steel used in the manufacture of steel wire of ACSR conductor is given below for guidance:

Element	Percentage composition
Carbon	0.50 to 0.8
Manganese	0.50 to 1.10
Phosphorus	Max to 0.035
Sulphur	Max 0.045
Silicon	0.10 to 0.35

Lay Ratios of Aluminium conductors, Galvanized Steel-Reinforced

(Clauses 10.2,10.3, and 13.8)

Number of Wires		Ratio of Aluminium wire Diameter To steel Wire Diameter	Lay Ratios for Aluminium Wire							
			Lay Ratios for Steel core (16 wire Layer)	Outermost layer	Layer immediately beneath Outermost layer		Innermost Layer of Conductors with 3 Aluminium Wire Layers			
Alu.	Steel		Min	Max	Min	Max	Min	Max	Min	Max
1	2	3	4	5	6	7	8	9	10	11
6	1	1.0	-	-	10	14	-	-	-	-
6	7	3.0	1.3	28	10	14	-	-	-	-
30	7	3.0	1.3	28	10	14	10	16	-	-
42	7	1.8	1.3	28	10	14	10	16	10	17
54	7	1.0	1.3	28	10	14	10	16	10	17

Stranding Constants
(Table I and Clauses 13.6, A-2, 1, A-2, 2 and A-2, 3, 1)

Number of Wires in Conductor		Mass Aluminium	Stranding Constant	
Aluminium	Steel		Steel	
(1)	(2)	(3)	(4)	(5)
6	0	6.091	1.000	0.169 2
6	7	6.091	7.032	0.169 2
30	7	30.67	1.032	0.034 08
42	7	42.90	7,032	0.024 32
54	7	55.23	7.032	0.018 94

GROUND WIRES FOR TRANSMISSION LINES - COMMONLY USE SIZES AAAC WIRES

Sr. No	Description	Unit	19/200	7/3.81	19/2.46
1	Nominal area	sq. mm	60	80	90
2	Sectional area				
	AAAC	sq. mm	59.70	79.81	90.31
	Steel	sq. mm			
	Total	sq. mm	59.70	79.81	90.31
3	Over all diameter	mm	10.00	11.43	12.30
4	Approximate mass	kg/mm	164	218	248
5	Rated Strength	kN kg	17.56 1790	23.41 2387	3.30 2576
6	Modulus of elasticity	kg sq. mm	0.57 x 10	0.6 x 10	0.57x 10
7	coefficients of linear expansion ° C	per	23.0 x 10	23.0 x 10	23.0 x 10
8	Electrical resistance	ohms	0.552	0.4125	0.3663
9	Tension / Sag		T	S	TSTS

	Span (m)	Temp (C)		(Kg f)	(m)	(Kg f)	(m)	(Kg f)	(m)
	260 53	32 293	358 04.73	03.87 389	477 0.7	03.86 425	515 04.93	04.07	
	275 53	32 297	358 05.23	04.33 394	77 05.24	04.32 430	515 05.45	04.55	
	320 53	32 306	358 06.86	05.86 407	477 06.86	05.85 444	515 07.16	06.16	
	350 53	32 311	358 08.07	07.01 414	477 08.07	07.00 451	515 08.42	07.37	
	380 53	32 316	358 09.37	08.27 420	477 09.37	08.25 458	515 09.78	08.69	
	400 53	32 319	358 10.29	09.16 424	477 10.24	09.14 462	515 10.75	09.63	

GROUND WIRES FOR TRANSMISSION LINES - COMMONLY USE SIZES

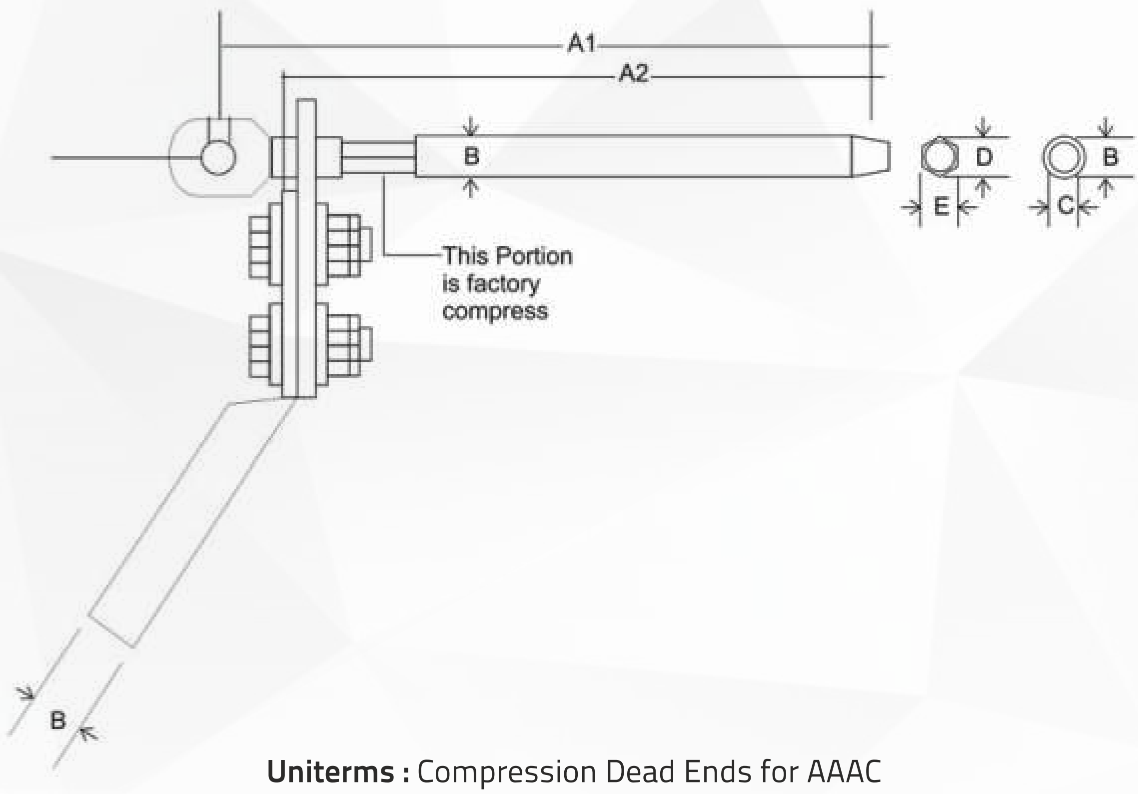
Galvanized Steel Wires

Sr. No	Description		Unit	7/3.15		7/3.66		7/4.06	
1	Nominal area		sq. mm	55		75		90	
2	Sectional area								
	AAAC		sq. mm	-		-		-	
	Steel		sq. mm	54.55		73.65		90.62	
	Total		sq. mm	54.55		73.65		90.62	
3	Over all diameter		mm	9.45		10.98		12.18	
4	Approximate mass		kg/mm	428		575		706	
5	Rated		kN	56		79.77		980.16	
	Strength		kg	5710		8134		10010	
6	Modulus of elasticity		kg sq. mm	$1.933x\ 10^{-6}$		$1.933x\ 10^{-6}$		$1.933x\ 10^{-6}$	
7	Coefficients of linear expansion ° C		per	$11.5x\ 10^{6}$		$11.5x\ 10^{6}$		$11.5x\ 10^{-6}$	
9	Tension / Sag			T	S	T	S	T	S
	Span (m)	Temp (C)		(Kg f)	(m)	(Kg f)	(m)	(Kg f)	(m)
	260	32		1142	3.17	1627	2.99	2002	2.98
		53		1007	3.59	1430	3.40	1760	3.39
	275	32		1142	3.54	1627	3.78	2002	3.33
		53		1013	3.99	1439	3.78	1770	3.77
	320	32		1142	4.80	1627	4.52	2002	4.51
		53		1041	6.30	1477	5.96	1817	5.02
	350	32		1142	5.74	1627	5.41	2002	5.40
		53		1041	6.30	1477	5.96	1817	5.95
	380	32		1142	6.76	1627	6.38	2002	6.37
		53		1050	7.36	1490	6.97	1833	6.95
	400	32		1142	7.50	1627	7.07	2002	7.05
		53		1056	8.11	1497	7.68	1842	7.67

DEAD END COMPRESSION CLAMPS

Sr. No.	CONDUCTOR			A1	A2	B	C	D	E
	NORMAL ALU. AREA	CONSTRUCTION	Outer DIAMETER						
	Sq. mm	Nos./mm	mm	mm	mm	mm	mm	mm	mm
1	100	19/2.79	13.95	280	250	30	15.50	29.4	25
2	150	37/2.49	17.43	350	314	33	19.1	32.6	28
3	200	37/2.88	20.16	405	363	38	22.1	37.0	32
4	300	37/3.19	22.33	457	399	38	24.2	37.0	32
5	400	37/3.92	27.44	550	494	48	29.45	46.0	40
6	420	61/3.19	28.71	620	517	48	31.0	46.0	40
7	520	61/3.55	31.95	640	575	54	34.5	53.0	46
8	560	61/3.68	33.12	665	596	54	35.7	53.0	46

NOTE:
The dimensions after compression are same as that MID SPAN JOINT. It is not a general practice for utility to use DEAD END CLAMP COMPRESSION upto 80 sq. mm. All dimensions are in mm.



Uniterms : Compression Dead Ends for AAAC

MID SPAN COMPRESSION JOINT FOR AAA CONDUCTORS.

Sr. No.	CONDUCTOR			A	B	C	D	E
	NORMAL ALU. AREA	CONSTRUCTION	Outer DIAMETER					
	Sq. mm	Nos./mm	mm	mm	mm	mm	mm	mm
1	100	19/2.79	13.95	350	30	15.50	29.40	25
2	150	37/2.49	17.43	440	33	19.10	32.60	28
3	200	37/2.88	20.16	510	38	22.10	37.00	32
4	300	37/3.19	22.33	610	38	24.20	37.00	32
5	400	37/3.92	27.44	690	48	29.45	46.00	40
6	420	61/3.19	28.71	711	48	31.00	46.00	40
7	520	61/3.55	31.95	800	54	34.50	53.00	46
8	560	61/3.68	33.12	830	54	35.70	53.00	46

REPAIR SLEEVE

Sr. No.	CONDUCTOR			A	B	C	D	E
	NORMAL ALU. AREA	CONSTRUCTION	Outer DIAMETER					
	Sq. mm	Nos./mm	mm	mm	mm	mm	mm	mm
1	100	19/2.79	13.95	139	30	15.5	29.4	25
2	150	37/2.49	17.43	175	33	19.1	32.6	28
3	200	37/2.88	20.16	210	38	22.1	37.0	32
4	300	37/3.19	22.33	241	38	24.2	37.00	32
5	400	37/2.92	27.44	275	48	29.45	46.00	40
6	420	61/3.19	28.71	287	48	31.0	46.00	40
7	520	61/3.55	31.95	320	54	34.5	53.00	46
8	560	61/3.68	33.12	332	54	35.7	53.00	46

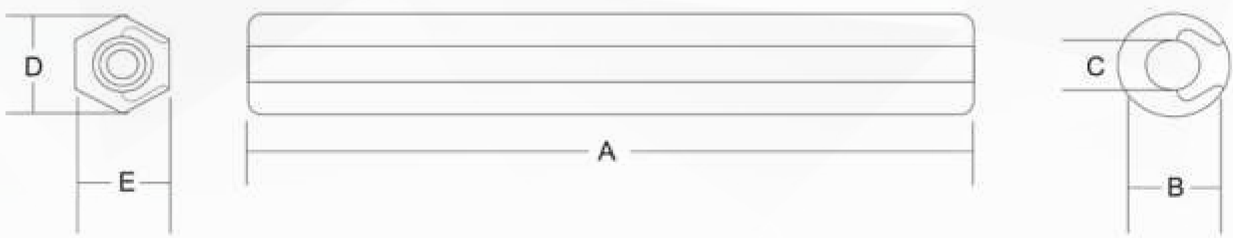


Fig.1 Drum NomenclatureCONDUCTOR PACKING: DRUM DIMENSIONS TO IS 1778/1980

Drum Component (mm)	Constructional Details for Drum Components				
1	2	3	4	5	6
Flange diameter	965	1065	1195	1220	1345
Barrel diameter	585	600	600	600	600
Traverse	510	710	710	710	710
Flange thickness	2x 25	2x 32	2x 32	2x 32	2x 32
Bore Diameter	80	80	80	80	80
Nail Circle	3	5	5	5	5
Nail length	65	75	75	75	75
Nail Size (Min.)	3.25	3.25	3.25	3.25	3.25
Thickness of Barrel end supports	38	38	38	38	38
Thickness of Barrel end lagging	38	38	38	38	38
No. of stretchers	4	4	4	4	4
Stretchers size	100x 38	100x 38	100x 38	100x 38	100x 38
No. of Bolts	4	4	4	4	4
Diameter of bolts (Min.)	12	12	12	12	12
Size of square washer	50x 6	50x 6	50x 6	50x 6	500 6
Size of spindle plate	150x 150x 6	150x 150x 6	150x 150x 6	150x 150x 6	150x 150x 6
Diameter of spindle plate hole	90	90	90	90	90
No, of Spindle plate bolt	4	4	4	4	4
Spindle plate bolt diameter	12	12	12	12	12
Thickness of external logging	38	38	38	38	38
No. of binders over external lagging	2	2	2	2	2

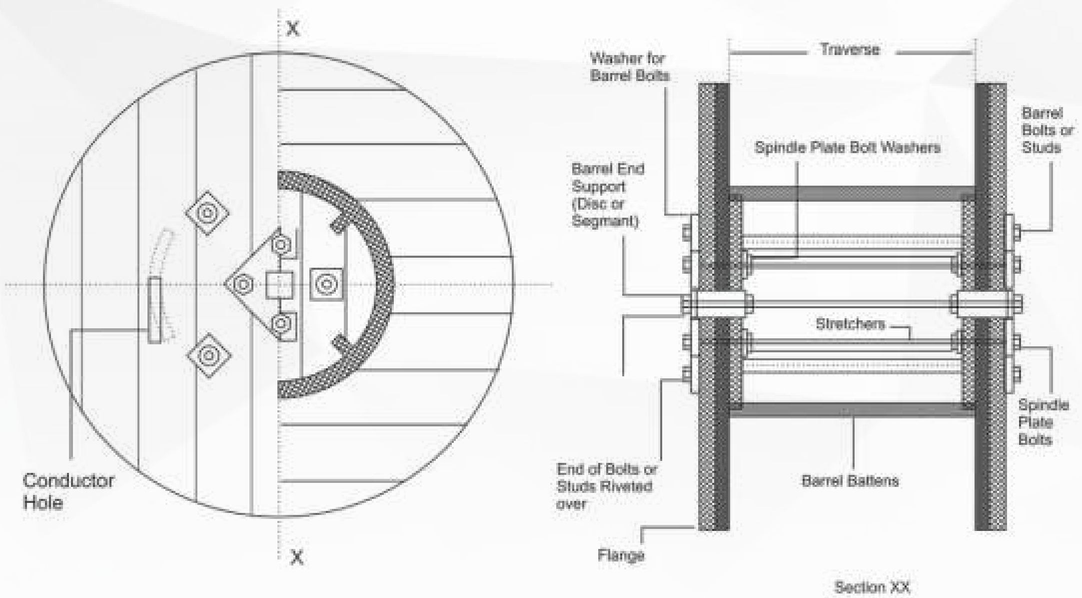


Fig.1 Drum Nomenclature

CONDUCTOR PACKING: DRUM DIMENSIONS TO IS 1778/1980

Drum Component	Constructional Details for Drum Components					
1	7	8	9	10	11	12
Flange diameter	1370	1475	1615	1725	1100	1900
Barrel diameter	600	600	685	710	750	1500
Traverse	710	710	812	812	600	600
Flange thickness	2x 32	2x 32	2x 33	2x 33	2x 32	2x 33
Bore Diameter	80	80	100	100	54x 54	105x 105
Nail Circle	5	5	6	6	5	5
Nail length	75	75	89	89	75	75
Nail Size(M in.)	3.25	3.25	3.65	3.65	3.25	3.25
Thickness of barrel end supports	50	50	50	50	38	50
Thickness of barrel end lagging	38	50	50	50	38	50
No. of stretchers	6	6	6	6	4	4
Stretchers sizes	100x 33	100x 50	1000 50	100x 50	75x 50	75x 75
No. of bolts	6	6	6	6	4	4
Diameter of bolt (Min.)	12	19	19	19	19	22
Size of square washer	50x 6	500 6	50x 63	50x 6	75x 6	100x 6
Size of spindle plate	230x 230x 6	230x 230x 6	230x 230x 6	230x 230x 6	230x 230x 6	380x 380x 6
Diameter of spindle plate hole	90	90	90	90	-	
No. of spindle plate bolt	4	4	4	4	4	4
Spindle plate bolt diameter	12	12	12	12	16	16
Thickness of external lagging	38	50	50	50	38	50
No. of binders over external lagging	3	3	3	3	2	3

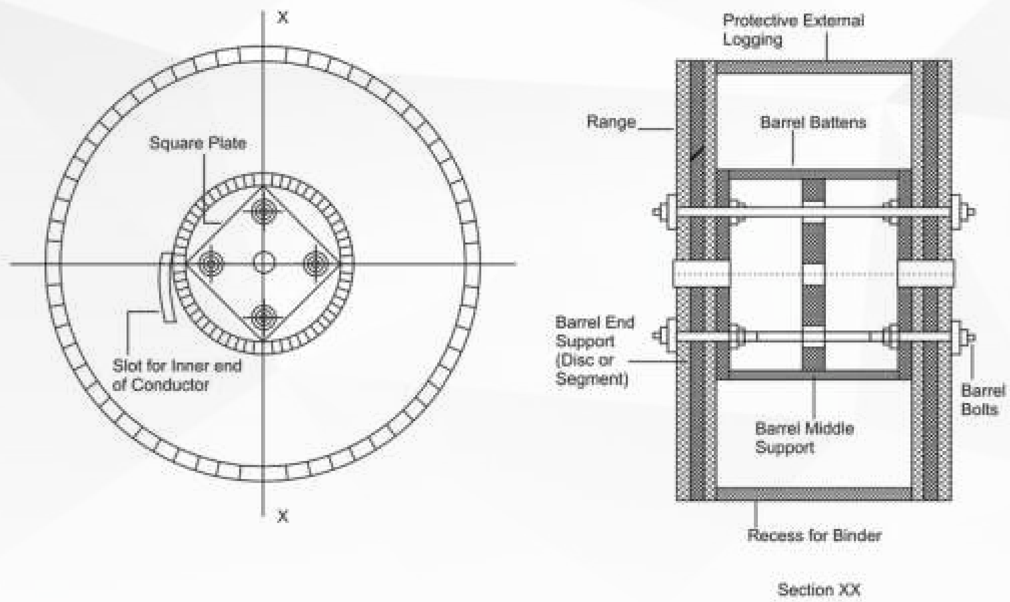


Fig. 2 Drum having 3 ply flange construction with barrel middle supports.

VARIOUS INTERNATIONAL STANDARDS

ALL ALUMINIUM STANDARD CONDUCTORS - BARE (TO BS: 215 PART 1)

Code Word	Aluminium Area mm²	Standard Nominal Copper Area/mm²	Standing Number & Diameter Of Wires mm		Diameter of Conductor mm	Rated Ultimate Strength Kg.	D-C Resistance at 20° C	Weight Kg/Km.
			No.	Diameter			Ω/Km.	
Midge	23.29	14.19	7	2.06	6.17	430	1.22700	63.5
Aphis	26.45	16.13	3	3.35	7.21	445	1.08100	72.5
Gnat	26.84	16.13	7	2.21	6.63	490	1.06400	73.4
Weevil	31.55	19.35	3	3.66	7.87	520	0.90780	86.3
Mosquito	36.90	22.58	7	2.59	7.77	645	0.77420	100.9
Ladybird	42.90	25.81	7	2.79	8.38	740	0.66550	117.3
Ant	52.77	32.26	7	3.1	9.3	890	0.54110	144.3
Fly	63.68	38.71	7	3.4	10.21	1050	0.44860	174.0
Bluebottle	73.55	45.16	7	3.66	10.97	1195	0.38840	201.0
Earwig	78.77	48.39	7	3.78	11.37	1275	0.36280	215.3
Grasshopper	84.13	51.61	7	3.91	11.73	1355	0.33950	229.9
Clegg	95.35	58.06	7	4.17	12.50	1520	0.29950	260.7
Wasp	106.2	64.52	7	4.39	13.18	1675	0.26910	290.0
Beetle	106.10	64.52	19	2.67	13.33	1810	0.27050	292.0
Bee	132.10	80.64	7	4.90	14.71	2060	0.21620	362.0
Cricket	157.90	96.77	7	5.36	16.08	2450	0.18090	432.0
Hornet	157.70	96.77	19	3.25	16.26	2575	0.18210	433.0
Caterpillar	185.90	112.90	19	3.53	17.65	2985	0.15440	510.0
Chafer	213.80	129.00	19	3.78	18.92	3390	0.13430	588.0
Spider	237.30	145.20	19	3.99	19.94	3735	0.12100	652.0
Cockroach	265.30	161.30	19	4.22	21.08	4135	0.10820	729.0
Butterfly	322.40	193.50	19	4.65	23.24	4940	0.08910	885.0
Moth	373.60	225.80	19	5.00	25.02	5700	0.07686	1027.0
Drone	372.60	225.80	37	3.58	25.07	5730	0.07748	1030.0
Locust	428.60	258.10	19	5.36	26.80	6515	0.06698	1177.0
Centipede	416.30	258.10	37	3.78	26.49	6325	0.06941	1150.0
Maybug	486.00	290.30	37	4.09	28.63	7290	0.05943	1342.0
Scorpion	529.00	322.60	37	4.27	29.87	7870	0.05459	1463.0
Cicada	627.80	387.10	37	4.65	32.54	9210	0.04601	1735.0
Tarantula	795.60	483.90	37	5.23	36.63	11570	0.03630	2198.0

ALL ALUMINIUM CONDUCTORS - BARE (AMERICAN SIZES)

Code Name	Equivalent Copper size		Standing Number & Diameter Of Wires mm		Dia. of complete Cable mm	Aluminium area of complete cable		Approx. ultimate Tensile Strength Kg	Standard Resistance at 20°C	wt. in Kg/km.
	AWG	Nominal area mm²	No.	Dia. mm.		Gauge AWG	mm²		II /Km.	
Rose	6	13.3	7	1.961	5.883	4	21.15	415	1.351	57.7
Lily	5	16.77	7	2.202	6.606	3	26.67	515	1.072	72.8
Iris	4	21.15	7	2.474	7.442	2	33.62	635	0.85	91.8
Pansy	3	26.67	7	2.776	8.328	1	42.41	775	0.674	115.8
Poppy	2	33.62	7	3.119	9.357	1/0	53.49	940	0.534	146.1
Aster	1	42.41	7	3.503	10.509	2/0	67.43	1185	0.424	184.2
Phlox	1/0	53.49	7	3.932	11.796	3/0	85.01	1435	0.336	232.3
Oxlip	2/0	67.43	7	4,417	13.251	4/0	107.20	1810	0.267	292.9
Daisy	3/0	85.01	7	4.958	14.874	266.800	135.20	2280	0.211	369.2
Peony	188,800	95.60	19	3.193	15.965	300.000	152.00	2670	0.189	417.4
Tulip	4/00	107.20	19	3.381	16.905	336.400	170.50	2995	0.168	467.3
Canna	250.000	126.70	19	3.673	18.365	397.500	201.40	3470	0.142	553.0

ALUMINIUM CONDUCTOR STEEL REINFORCED - BARE (AMERICAN SIZE)

Code Word	Aluminium Area		Area of Complete Conductor mm²	Copper Equivalent mm²	Standing No. and Dia. of Wires mm.				Diameter mm		Rated Ultimate Tensile Strength (kg)	D-C Resistance at 20°C (Ω/km)	Weight kg/km		
					Aluminium		Steel								
	Circular Mils	mm²			No.	Dia	No.	Dia	Complete conductor	Steel Core			Total	Alum.	Steel
Chickadee	397500	201.42	212.58	126.68	18	3.77	1	3.77	18.87	3.77	4717	0.14270	641.5	554.4	87.1
Pelican	477000	241.68	255.10	152.01	18	4.14	1	4.14	20.68	4.14	5579	0.11890	770.9	666.3	104.6
Flicker	477000	241.68	273.03	152.01	24	3.58	7	2.39	21.48	7.16	7802	0.11950	914.1	669.7	244.4
Osprey	556500	282.00	297.68	177.35	18	4.47	1	4.47	22.33	4.47	6509	0.10180	898.8	776.8	122.0
Parakeet	556500	282.00	318.52	177.35	24	3.87	7	2.58	23.22	7.75	9004	0.10250	1066.8	7813	285.5
Peacock	605000	306.58	346.39	192.80	24	4.03	7	2.69	24.21	8.08	9798	0.09420	1159.2	849.8	309.5
Squab	605000	306.58	356.45	192.80	26	3.87	7	3.01	24.54	9.40	10954	0.09420	1267.8	849.8	389.8
Teal	605000	306.58	376.45	192.80	30	3.61	19	2.16	25.25	10.82	13630	0.09432	1397.4	851.2	546.2
Rook	636000	322.26	364.00	202.68	24	4.14	7	2.76	24.82	8.28	10274	0.08966	1218.7	892.9	325.8
Flamingo	666600	337.74	381.55	212.31	24	4.23	7	2.82	25.40	8.46	10773	0.08550	1277	936.0	341.0
Tern	795000	402.84	430.71	253.35	45	3.38	7	2.25	27.00	6.76	10410	0.07177	1333	1116.0	217.0
Rail	954000	483.42	516.84	304.03	45	3.70	7	2.47	29.59	7.39	12202	0.05981	1600	1339.0	216.0
Ortlan	1033500	523.68	559.93	32 .36	45	3.85	7	2.57	30.81	7.70	13041	0.05522	1734	1451.0	283.0
Bluejay	111300	563.93	602.97	354.70	45	4.00	7	2.66	31.98	8.00	14039	0.05127	1875	1570.0	305.0
Bunting	1192500	604.26	646.00	380.03	45	4.14	7	2.76	33.07	8.28	15059	0.04785	2007	1681.0	326.0
Bittern	1272000	644.51	689.10	405.37	45	4.27	7	2.85	34.16	8.53	16057	0.04486	2143	1795.0	348.0
Dipper	1351500	685.16	732.26	430.70	45	4.40	7	2.92	35.18	8.76	17010	0.04222	2275	1906.0	369.0
Bobolink	1431000	725.16	775.48	456.04	45	4.53	7	3.02	36.25	9.07	18053	0.03988	2411	2019.0	392.0
Nuthatch	1510500	765.16	818.06	481.37	45	4.65	7	3.10	37.21	9.30	18869	0.03988	2543	2131.0	412.0
Lapwing	1590000	805.80	861.29	506.71	45	4.77	7	3.18	38.15	9.55	19867	0.03589	2677	2243.0	434.0
Chukar	1780000	901.93	975.48	567.00	84	3.70	19	2.22	40.69	11.10	24312	0.03212	3086	2510.0	576.0

ALUMINIUM CONDUCTORS -BARE (CANADIAN STANDARD SIZES)

Code Word	Aluminium Area		Copper equivalent mm²	Stranding, Number and diameter of wires (mm)		Dia. of conductor mm.	Rated ultimate strength Kg.	D-C Resistance 20 °C	wt. in Kg/km.
	AWG of circular Mills	mm²		No.	Dia.			Ω /Km.	
Rose	4	21.15	13.3	7	1.961	5.89	415	1.3510	57.7
Lily	3	26.67	16.77	7	2.202	6.60	515	1.0720	72.8
Iris	2	33.62	21.15	7	2.474	7.42	635	0.8500	91.8
Pansy	1	42.41	26.67	7	2.776	8.34	775	0.6740	115.8
Poppy	1/0	53.49	33.62	7	3.119	9.36	940	0.5340	146.1
Aster	2/0	67.43	42.41	7	3.503	10.55	1185	0.4240	184.2
Phlox	3/0	85.01	53.49	7	3.932	11.79	1435	0.3360	232.3
Oxlip	4/0	107.20	67.43	7	4.417	13.26	1810	0.2670	292.9
Daisy	266,800	135.20	85.01	7	4.958	14.88	2280	0.2110	369.2
Peony	300,000	152.00	95.60	19	3.193	15.98	2670	0.1890	417.4
Tulip	396,400	170.50	107.20	19	3.381	16.92	2995	0.1680	467.3
Canaa	397,500	201.40	126.70	19	3.673	18.36	3470	0.1420	553.0
Cosmos	477,000	241.70	152.00	19	4.023	20.12	4080	0.1190	663.5
Zinnia	500,000	253.30	159.40	19	4.120	20.60	4275	0.1130	695.6
Dahlia	556,500	282.00	177.40	19	4.346	21.75	4760	0.1020	774.2
Orchid	636,000	322.30	202.70	37	3.330	23.31	5665	0.0895	888.9
Violet	715,500	362.50	228.00	37	3.533	24.71	6375	0.0795	1000.0
Petunia	750,000	380.00	239.00	37	3.617	25.32	6545	0.0758	1048.0
Arbutus	795,000	402.80	253.40	37	3.724	26.04	6940	0.0715	1111.0
Anemone	874,500	443.10	278.70	37	3.904	27.33	7475	0.0652	1222.0
Magnolia	954,000	483.40	304.00	37	4.079	28.56	8155	0.0597	1333.0
Bluebell	1.033,500	523.70	329.40	37	4.244	29.75	8835	0.0551	1445.0
Marigold	1,113,000	564.00	354.70	61	3.432	30.87	9910	0.0513	1560.0
Hawthorn	1.192,500	604.20	380.00	61	3.551	31.95	10615	0.0478	1670.0
Narcissus	1,272,000	644.50	405.40	61	3.668	33.02	11090	0.0449	1781.0
Columbine	1.351,500	684.80	430.70	61	3.780	34.01	11795	0.0423	1893.0
Carnation	1,431,000	725.10	456.00	61	3.891	35.03	12225	0.0399	2005.0
Gladiolus	1,510,500	765.40	481.40	61	3.998	36.00	12905	0.0378	2116.0
Coreopsis	1,590,000	805.70	506.70	61	4.100	36.91	13585	0.0359	2226.0

ALUMINIUM CONDUCTOR STEEL REINFORCED (CANADIAN STANDARD SIZES)

Code Word	Aluminium Area		Area of Complete Conductor mm²	Copper Equivalent mm²	Standing No. and Dia. of Wires mm.		Diameter mm		Rated Ultimate Tensile Strength (kg)	D-C Resistance at 20°C (Ω/km)	Weight kg/km		
	AWG or Circular Mils	mm²			Aluminium	Steel	Complete conductor	Steel Core			Total	Alum.	Steel
Wren	8	8.37	9.81	5.26	6/1.33	1/1.33	3.99	1.33	340	3.423	33.77	22.89	10.88
Warbler	7	10.55	12.34	6.63	6/1.50	1/1.50	4.5	1.5	425	2.714	42.53	28.86	13.68
Turkey	6	13.3	15.46	8.37	6/1.68	1/1.68	5.04	1.68	530	2.154	53.61	36.39	17.22
Thrush	5	16.77	19.55	10.55	6/1.89	1/1.89	5.67	1.89	660	1.707	67.64	45.88	21.76
Swan	4	21.15	24.75	13.3	6.2.12	1/2.12	6.36	2.12	830	1.354	85.31	57.89	27.42
Swallow	3	26.67	31.1	16.77	6/2.38	1/2.38	7.14	2.38	1025	1.074	107.6	72.97	34.61
Sparrow	2	33.62	39.22	21.15	6/2.67	1/2.67	8.01	2.67	1265	0.8507	135.6	92.02	43.63
Robin	1	42.41	49.48	26.67	6/3.00	1/3.00	9	3	1585	0.6754	171.1	116.1	55
Raven	36526	53.49	62.38	33.62	6/3.37	1/3.37	10.11	3.37	1940	0.5351	215.9	146.5	69.4
Quail	36557	67.43	78.64	42.41	6/3.78	1/3.78	11.34	3.78	2425	0.4245	272.1	184.6	87.5
Pigeon	36617	85.01	99.23	53.49	6/4.25	1/4.25	12.75	4.25	3030	0.3367	342.9	232.7	110.2
Penguin	266800	107.2	125.1	67.43	6/4.77	1/4.77	14.31	4.77	3820	0.2671	432.5	293.5	139
Partridge	266800	135.2	157.2	85.01	26/2.57	7/2.00	16.28	6	5100	0.2137	545.4	373.5	171.9
Owl	266800	135.2	152.7	85.01	6/5.36	7/1.79	16.09	5.37	4330	0.2118	506.8	370.1	136.7
Waxwing	300000	135.2	142.6	85.01	18/3.09	1/3.09	15.47	3.09	3210	0.2126	429.8	371.5	583.4
Pi per	300000	152	187.5	95.60	30/2.54	7/2.54	17.78	7.62	7000	0.1902	697	420.2	276.8
Ostrich	336400	152	176.7	95.60	26/2.73	7/2.12	17.28	6.36	5730	0.19	612.7	419.7	193
Oriole	336400	170.5	210.3	107.20	30/2.69	7/2.69	18.83	8.07	7735	0.1696	781.6	471.3	310.3
Linnet	336400	170.5	198.3	107.20	26/2.89	7/2.25	18.31	6.75	6375	0.1694	687.4	470.7	216.7
Merlin	336400	170.5	179.9	107.20	18/3.47	1/3.47	17.37	3.47	4060	0.1686	542	468.4	73.6
Lark	397500	201.4	248.4	126.70	30/2.92	7/2.92	20.44	8.76	9060	0.1435	923.3	556.6	366.7
Ibis	397500	201.4	234.2	126.70	26/3.14	7/2.44	19.88	7.32	7340	0.1434	811.7	556.1	255.6
Hen	477000	241.7	298.1	152.00	30/3.20	7/3.20	22.4	9.6	10590	0.1196	1108	668	440
Eagle	556500	282	347.8	177.40	30/3.460	7/3.460	24.22	10.38	12360	0.1025	1293	779	514
Dove	556500	282	327.9	177.40	26/3.720	7/2.890	23.55	8.67	10190	0.1025	1137	779	358
Duck	605000	306.6	346.4	192.80	54/3.690	7/2.690	24.21	8.07	10210	0.09439	1158	848	310
Egret	636000	322.3	395.6	202.70	30/3.700	19/2.220	25.9	11.1	14330	0.08973	1466	891	575
Grosbeak	636000	322.3	374.7	202.70	26/3.970	7/3.090	25.15	9.27	11340	0.08966	1299	890	409
Goose	636000	322.3	364	202.70	54/2.760	7/2.760	24.81	8.27	10730	0.08979	1218	892	326
Gull	666600	337.8	381.5	212.30	54/2.820	7/2.820	25.38	8.47	11140	0.08569	1276	935	341
Redwing	715500	362.5	445.1	228.00	30/3.920	19/2.350	27.43	11.76	15690	0.07978	1648	1002	646
Staring	715500	362.5	421.6	228.00	26/4.210	7/3.280	26.68	9.83	12750	0.07966	1462	1001	164
Crow	715500	362.5	409.5	228.00	54/2.920	7/2.920	26.28	8.77	11950	0.07985	1370	1003	367
Mallard	795000	402.8	494.7	253.40	30/4.140	19/2.480	28.96	12.41	17440	0.07177	1833	1144	719
Drake	795000	402.8	468.5	253.40	26/4.442	7/3.454	28.14	10.36	14175	0.07171	1624	1113	512
Condor	795000	402.8	455.1	253.40	54/3.084	7/3.084	26.76	9.25	12950	0.07183	1522	1114	408
Crane	874500	443.1	500.6	278.70	54/3.233	7/3.233	29.11	9.7	14245	0.06531	1674	1226	448
Canary	900000	456.1	515.2	286.80	54/3.279	7/3.279	29.51	9.84	14650	0.06344	1723	1262	461
Cardinal	954000	483.4	546.1	304.00	54/3.376	7/3.376	30.38	10.13	15535	0.05988	1826	1337	489
Curlew.	1033500	523.7	291.6	329.40	54/3.515	7/3.515	31.65	10.55	16850	0.05527	1979	1449	530
Finch	111300	563.9	635.5	354.70	51/3.647	19/2.189	32.84	10.95	18238	0.05133	2120	1560	560
Grackel	1192500	604.3	680.8	380.00	54/3.774	19/2.266	33.99	11.33	19550	0.0479	2271	1672	590
Pheasant	1272000	644.5	726.2	405.40	54/3.900	19/2.339	35.36	11.7	20320	0.0449	2422	1783	639
Martin	1351500	684.8	771.5	430.70	54/4.018	19/2.410	36.17	12.05	21590	0.04227	2574	1895	679
Plover	1431000	725.1	817	456.00	54/4.135	19/2.482	37.21	12.41	22860	0.03992	2275	2006	719
Parrot	1510500	765.4	862.4	481.40	54/4.249	19/2.550	38.25	12.75	24175	0.03782	2877	2118	759
Falcon	1590000	805.7	907.8	506.70	54/4.359	19/2.616	39.24	13.08	25445	0.03592	3028	2229	799

ALUMINIUM CONDUCTOR STEEL REINFORCED - ACSR (EUROPEAN STANDARD SIZES)

Code Word	Nom Copper area	Standing & wire diameter		Area of Alu.	Area of Complete Conductor	Diameter mm		Resistance at 20°C	Approx. Ultimate strength of contd.	Approximately weight of conductor			Km/ kg	Standard length of drum	Approximately Net weight of conductor drum	
		Alum.	Steel			Complete conductor	Steel Core			Alum.	Steel	Total			Ungreased	Greased
	mm^2	mm	mm	mm^2	mm^2			Q /km	kg	kg.	kg.	kg.		m	kg	kg
Calibri	10	6/1.84	1/1.84	15.95	18.61	5.52	1.84	1.808	610.5	43.7	20.9	64,6	0.8	2x 4247	548	555
Randine	16	5/2.32	1/2.32	25.35	29.58	6.96	2.32	1.137	920.8	69.3	23	102.3	1.2	2x 2671	548	555
Fringuelio	25	6/2.90	1/2.90	39.64	46.25	8.70	2.9	0.727	1408	108	52	160	2	2x 1707	548	555
Carvo	35	6/3.44	1/3.44	55.74	65.03	10.32	3.44	0.517	1956	152	73	225	2.7	2428	548	555
Gufo	35	26/1.65	7/1.28	55.69	64.72	10.44	3.84	0.524	2114	154	71	225	4.4	2x 4556	2053	2093
Merlo	35	30/1.54	7/1.54	55.74	68.75	10.78	4.62	0.522	2608	155	102	257	5.8	2x 3301	1561	1595
Quaglia	50	6/4.11	1/4.11	79.59	92.85	12.33	4.11	0.362	2771	218	104	322	3.9	1701	548	555
Fragrance	50	6/4.11	7/1.37	79.59	89.83	12.33	4.11	0.362	2503	218	81	299	6.7	1715	513	524
Colombo	50	26/1.97	7/1.53	79.17	92.04	12.47	4.59	0.368	2971	219	101	320	6.2	2x 3208	2053	2093
Cincia	50	30/1.84	7/1.84	79.74	98.25	12.88	5.52	0.356	3694	221	147	368	8.3	2x 2123	1561	1596
Canario	70	6/4.85	1/4.85	111.25	129.79	14.58	4.85	0.26	3873	305	145	450	5.4	1217	548	555
Sparviero	70	6/4.85	7/1.62	111.25	125.7	14.58	4.86	0.26	3504	305	114	419	9.3	1226	513	524
Pemice	70	26/2.33	7/1.81	110.90	128.73	14.75	5.43	0.263	4091	307	142	449	8.7	2x 2265	2053	2093
Civetta	70	30/2.17	7/2.17	110.71	136.78	15.19	6.51	0.263	4890	307	204	511	12	3053	1561	1596
struzzo	95	26/2.72	7/2.12	151.14	175.88	17.24	6.36	0.193	5348	419	195	614	12	3343	2053	2093
Gru	95	30/2.53	7/2.53	150.77	185.95	17.71	7.59	0.193	6563	417	278	695	16	2245	1561	1595
Zigolo	120	26/3.06	7/2.38	191.23	222.39	19.38	7.14	0.152	6677	530	246	776	15	2646	2.053	2.093
Ghiandaia	120	30/285	7/2.85	191.42	235.03	19.95	8.55	0.152	8255	530	352	882	20	1768	1.561	1.595
Rigogolo	150	26/3.42	7/2.66	238.70	277.55	21.66	7.98	0.122	8474	661	307	968	19	2120	2.053	2093
Fanello	150	30/3.18	7/3.18	238.26	293.85	22.26	9.54	0.122	10206	660	439	1099	25	1420	156	1596
Allodola	185	26/3.80	7/2.95	294.89	343.03	24.08	8.88	0.0989	10170	817	380	1197	23	1715	2053	2093
Usignuola	185	30/3.53	7/3.53	293.61	352.12	24.71	10.59	0.0992	12501	813	541	1354	30	1152	1561	1596
Picchio	185	54/2.63	7/2.63	292.99	330.97	22.67	7.89	0.0995	9267	812	300	1112	17	2078	2312	2347
Falcone	240	26/4.32	7/3.35	381.11	443.21	27.36	10.08	0.0765	13109	1056	490	1546	30	1328	2053	2093
Airone	240	30/4.02	19/2.41	380.90	469.57	28.13	12.05	0.0733	15907	1030	689	1719	41	1236	2124	2175
Gazza	240	54/3.00	7/3.00	381.48	430.93	27.00	9	0.0764	11916	1057	390	1447	22	1597	2312	2346
Storno	300	54/3.35	7/3.35	475.95	537.59	30.15	10.05	0.0613	14724	1318	487	1805	27	1279	2312	2346
Beccaccia	400	54/3.87	19/2.32	634.76	715.05	34.82	11.6	0.0495	19241	1758	637	2395	37	891	2133	2165
Aquila	500	54/4.33	19/2.60	795.37	895.37	38.98	13	0.0367	24090	2203	802	3005	48	708	2124	2160

ALUMINIUM CONDUCTOR STEEL REINFORCED - ACSR (BRITISH STANDARD SIZES) BS 215 (PART - 2)

Code Word	Nom. Copper Area mm2	Standing & Wire Diameter				Aluminium Area mm²	Area of Complete Conductor mm²	Overall Diameter	Ultimate Tensile Strength (kg)	D-C Resistance at 20°C (Ω/km)	Weight kg/km		
		Aluminium		Steel									
		No.	Dia	No.	Dia						Total	Alum.	Steel
Mole	6.45	6	1.50	1	1.50	10.58	12.35	4.50	410	2.705	42.8	2.9	13.8
Squirrel	12.9	6	2.11	1	2.11	20.95	24.44	6.33	770	1.366	84.6	57.2	27.4
Gopher	16.13	6	2.36	1	2.36	26.30	30.68	7.08	955	1.089	106.0	71.9	34.1
Weasel	19.35	6	2.59	1	2.59	31.63	36.90	7.77	1135	0.9047	127.7	86.5	41.2
Fox	22.58	6	2.79	1	2.79	36.79	42.92	8.36	1310	0.778	148.5	100.6	47.9
Farret	25.81	6	3.00	1	3.00	42.35	49.41	9.00	1500	0.676	170.8	115.8	55.0
Rabbit	22.6	6	3.35	1	3.35	52.95	61.78	10.05	1860	0.5404	213.9	145.1	68.8
Mink	38.71	6	3.66	1	3.66	63.6	73.57	10.98	2205	0.054	254.8	172.8	82.0
Skunk	38.71	12	2.59	7	2.59	63.29	100.2	12.95	5270	0.457	464.5	174.7	289.8
Beaver	45.16	6	3.99	1	3.99	74.97	87.42	11.97	2615	0.382	302.7	205.2	97.5
Hors	45.16	12	2.79	7	2.79	73.55	116.51	13.97	6110	0.3929	540.3	203.2	337.1
Racoon	48.39	6	4.09	1	4.09	78.84	91.94	12.27	2745	0.3633	318.5	215.9	102.6
Otter	51.61	6	4.22	1	4.22	83.74	97.74	12.66	2915	0.3418	338.5	229.4	109.1
Cat	58.16	6	4.50	1	4.50	95.29	111.20	13.50	3315	0.3005	384.7	260.7	124.0
Hare	64.52	6	4.72	1	4.72	105.2	122.70	14.16	3660	0.2722	424.7	288.0	136.7
Dog	64.52	6	4.72	7	1.57	105.2	118.80	14.15	3310	0.2722	395.2	288.1	107.1
Hyena	64.52	7	4.39	7	1.33	106.2	126.60	14.57	4150	0.2697	451.5	296.6	160.9
Leopard	80.654	6	5.28	7	1.75	131.6	148.50	15.81	4120	0.2177	493.0	360.2	132.8
Coyote	80.65	26	2.54	7	1.91	131.7	151.70	115.18	4645	0.2198	521.7	365.0	156.7
Tiger	80.65	30	2.36	7	2.36	131.5	162.10	16.52	5790	0.2203	605.1	364.1	241.0
Wolf	96.77	30	2.59	7	2.59	158.1	195.00	18.13	6875	0.1831	727.7	43.8	28.7
Lynx	112.9	30	2.79	7	2.79	183.9	226.80	19.53	7945	0.1575	846.7	509.6	337.1
Panther	129	30	3.00	7	3.00	211.7	261.20	21.00	9095	0.1368	974.1	586.2	387.9
Lion	145.2	30	3.18	7	3.18	237.5	292.90	22.26	10160	0.1219	1093	657.8	435.2
Boar	161.3	30	3.35	7	3.37	264.8	326.60	23.50	11320	0.1093	1219.6	733.7	485.3
Goat	193.5	30	3.71	7	3.71	324.0	399.60	25.97	13765	0.08935	1491.3	897.7	593.6
Sheep	225.8	30	3.99	7	3.99	374.7	462.10	27.93	15900	0.0773	1725	1038	687.0
Antelope	225.8	54	2.97	7	2.97	374.5	423.10	26.73	11680	0.07736	1418	1037	381.0
Bison	225.8	54	3	7	3.00	380.2	430.50	26.97	11885	0.07606	1443	1055	388.0
Deer	258.1	30	4.27	7	4.27	429.1	529.20	29.89	18190	0.06748	1976	1189	787.0
Zebra	258.1	54	3.18	7	3.18	423.5	482.90	28.62	13245	0.06773	1619	1184	435.0
Elk	290.3	30	4.5	7	4.50	476.3	587.50	31.5	20185	0.06079	2192	1319	873.0
Camel	290.3	54	3.35	7	3.35	476.6	538.4	30.15	14740	0.06076	1805	1.32	485
Moose	322.6	54	3.53	7	3.35	528.5	597	31.77	16280	0.0548	2002	1464	538

Theoretical values valid upto 60 Hz for a wind velocity of 0.6 m/sec. and solar action for an initial temperature of 35 °C and an ultimate cable temperature of 80°C

In the case of unusual placement without air movement, these values will be reduced on an average of 90% approximately.

ALUMINIUM CONDUCTOR STEEL REINFORCED - ACSR (CANADIAN STANDARD SIZES)

Code Word	Cross sectional area		Total	Copper area mm^2	Stranding and wire diameter		Overall diameter mm^2	Weight kg/km			%wt		Ultimate Strength of Conductor kgs	D-C Resistance at 20°C Ω/km
	Alum. mm^2	Steel mm^2			Aluminium No/mm	Steel No/mm		Alum. Kg/k	Steel Kg/k	Total Kg/k	Alum.	Steel		
Wren	8.37	1.44	9.81	5.26	6/1.33	1/1.33	3.99	22.89	10.88	33.77	67.9	32.1	340	3.423
Warbler	10.55	1.77	12.32	6.63	6/1.50	1/1.50	4.50	28.86	13.67	42.53	67.9	32.1	425	2.714
Turkey	13.3	2.16	15.46	8.37	6/1.68	1/1.68	5.04	36.39	17.22	53.61	67.9	32.1	530	2.154
Thrush	16.77	2.78	19.55	10.55	6/1.89	1/1.89	5.67	45.88	21.76	67.64	67.9	32.1	660	1.707
Swan	21.15	3.56	24.71	13.3	6/2.12	1/2.12	6.36	57.89	27.42	85.31	67.9	32.1	830	1.354
Swallow	26.67	4.43	31.1	16.77	6/2.38	1/2.38	7.14	72.97	34.61	107.6	66.7	32.1	1025	1.074
Sparrow	32.62	5.6	39.22	21.15	6/2.67	1/2.67	8.01	92.02	43.63	135.6	67.9	32.1	1265	0.8507
Robin	42.41	7.07	49.48	26.67	6/3.00	1/3.00	9.00	116.1	55	171	67.9	32.1	1585	0.6754
Raven	53.49	8.89	62.38	36.62	6/3.37	1/3.37	10.11	146.5	69.4	215.9	67.9	32.1	1940	0.5351
Quill	67.43	11.21	78.64	42.41	6/3.78	1/3.78	11.34	184.6	87.5	272.1	67.9	32.1	2425	0.4245
Pigeon	85.01	14.22	99.23	53.49	6/4.25	1/4.25	12.75	232.7	110.2	342.9	67.9	32.1	3030	0.3367
Penguin	107.2	17.9	125.1	67.43	6/4.77	1/4.7	14.31	293.5	139	432.5	67.9	32.1	3820	0.2671
Partridge	135.2	22	157.2	85.01	26/2.57	7/2.00	16.28	373.5	171.9	545.4	68.5	31.5	5100	0.2137
Owl	135.2	17.5	152.7	85.01	6/5.36	7/1.79	16.09	370.1	136.7	506.8	73	27	4330	0.2118
Waxwing	135.2	7.4	142.6	85.01	18/3.09	1/3.09	15.47	371.5	583.4	429.8	86.4	13.6	3210	0.2126
Piper	152	35.5	187.5	95.6	30/2.54	7/2.54	17.78	420.2	276.8	697	60.3	39.7	7000	0.1902
Ostrich	152	24.7	176.7	95.6	26/2.73	7/2.12	17.28	419.7	193	612.7	68.5	31.5	5730	0.19
Oriole	170.5	39.8	210.3	107.2	30/2.69	7/2.69	18.83	471.3	310.3	781.3	60.3	39.7	7735	0.1696
Linnet	170.5	27.8	198.3	107.2	26/2.89	7/2.25	18.31	470.7	216.7	687.4	68.5	31.5	6375	0.1694
Marlin	170.5	9.4	179.9	107.2	18/3.47	1/3.47	17.37	468.4	73.6	542	86.4	13.6	4060	0.1686
Chickadee	201.4	11.2	212.6	126.7	18/3.77	1/3.77	18.87	554.4	87.1	641.5	86.4	13.6	4717	0.1427
Lark	201.4	47	248.4	126.7	3/2.92	7/2.92	20.44	556.6	366.7	923.3	60.3	39.7	9060	0.1435
Lbis	201.4	32.8	234.2	126.7	26/3.14	7/2.44	19.88	556.1	255.6	811.7	68.5	31.5	7340	0.1434
Pelican	241.7	13.4	255.1	152	18/4.14	1/4.14	20.68	663.3	104.6	770,9	86.4	13.6	5579	0.1189
Flicker	241.7	31.3	273	152	24/3.58	7/2.39	21.49	669.7	244.4	914.1	73.2	26.8	7802	0.1195
Hen	241.7	56.4	298.1	152	30/3.20	7/3.20	22.40	668	440	1108	60.3	39.7	10590	0.1196
Hawk	241.7	39.4	281.1	152	26/3.44	7/2.68	21.80	667.4	307.5	974.9	68.5	31.5	8820	0.1195
Heron	253.3	59.1	312.4	159.4	30/3.28	7/3.28	22.96	701	461	1162	60.3	39.7	11090	0.1141
XX	282	15.7	297.7	177.4	18/4.47	1/4.47	22.33	776.8	122	898.8	86.4	13.6	6509	0.1018
Parakeet	282	36.1	318.5	177.4	24/3.87	7/2.58	23.22	781	286	1067	73.2	26.8	9004	0.1025
Eagle	282	45.9	327.9	177.4	26/3.72	7/2.89	23.55	779	358	1137	68.5	31.5	10190	0.1025
Peacock	306.6	39.8	346.8	192.8	24/4.03	7/2.69	24.21	850	309	1159	73.1	26.9	9798	0.0942
Squab	306.6	49.9	356.5	192.8	26/3.87	7/3.01	24.54	850	308	1268	6.5	31.5	10954	0.0942
Teal	306.6	69.9	376.5	192.8	30/3.61	19/2.16	25.25	851	546	1397	60.8	39.2	13630	0.9439
Duck	306.6	39.8	346.4	192.8	54/2.69	7/2.69	24.21	848	310	1158	73.2	26.8	10210	0.9439
Rook	322.3	41.7	364	202.7	24/4.14	7/2.76	24.82	893	326	1219	73.2	26.8	10274	0.08966
Eg rit	322.3	73.3	395.6	202.7	30/3.70	19/2.22	25.90	891	575	1466	60.8	39.2	14330	0.08973
Grosbeak	322.3	52.4	374.7	202.7	26/3.97	7/3.09	25.15	890	409	1299	6.5	31.5	11340	0.08966
Goose	322.3	41.7	364	202.7	54/2.76	7/2.76	24.84	892	326	1218	73.2	26.8	10730	0.08979
Flaningo	337.8	43.8	381.6	212.3	24/4.23	7/2.82	25.38	936	341	1277	73.2	26.8	10773	0.0855
Gull	337	43.7	381.5	212.3	54/2.82	7/2.82	25.38	935	341	1276	73.2	26.8	11140	0.08569
Redwing	362.5	82.6	445.1	228	30/3.92	19/2.35	27.43	1002	646	1648	60.8	39.2	15690	0.07966
Starling	362.5	59.1	421.6	228	26/4.21	7/3.28	26.68	1001	461	1462	68.5	31.5	12750	0.7966

ALUMINIUM CONDUCTOR STEEL REINFORCED-ACSR (FRENCH STANDARD SIZED)

Area sq. mm³			Composition				Ext. diameter of conductor	Nominal Ultimate Strength	Elect, Resistance at 20 °C	Conductor Weight	Gross Weight		Modu. Of Elasticity	Coefficient of Expansion
			Alum.		Steel						Covered	Uncovered		
Total	Alum.	Steel	No.	mm	No.	mm	mm	kg.	Q/km.	Kg/km.	Kg/km.	Kg/km.	hbar	x 10^6
22	18.80	3.14	6	2.00	1	2.00	6	697	1.530	76	2.5	1.5	7.500	18.7
34.4	29.50	4.91	6	2.50	1	2.50	7.5	1055	0.977	120	4	2	7.500	18.7
37.7	28.27	9.43	9	2.00	3	2.00	8.3	1540	1.020	155	6	3	8.650	17.1
54.6	46.83	7.77	6	3.15	1	3.15	9.45	1620	0.616	190	7	2	7.500	18.7
59.7	37.71	21.99	12	2.00	7	2.00	10	3050	0.765	276	7	3	10.150	15.4
75.5	47.71	27.99	12	2.25	7	2.25	11.25	3840	0.605	348	8	3	10.150	15.4
116.2	94.24	22.00	30	2.00	7	2.00	14	4145	0.306	432	13	7	7.850	18
147.1	119.28	27.83	30	2.25	7	2.25	15.75	5200	0.243	547	17	8	7.850	18
181.6	147.26	34.34	30	2.50	7	2.50	17.5	6260	0.197	675	21	10	7.850	18
228	184.81	43.10	30	2.80	7	2.80	19.6	7710	0.157	848	26	13	7.850	18
288	233.79	54.55	30	3.15	7	3.15	22.05	9690	0.122	1.074	33	17	7.850	18
36.6	297.00	69.30	30	3.55	7	3.55	24.85	11975	0.098	1.376	43	22	7.850	18

The steel strands have an ultimate strength of 117.6hbars.
1 hectobar : 1.02kg./mrre
1 daN : 1.2kg./force
These cables are manufactured in accordance with the Standard NF; C 34-120.

CONSTANTS FOR DETERMINING AREA, WEIGHT AND RESISTANCE OF ACSR AND AAC

	All Aluminium Conductors				ACSR Aluminium conductors surrounding the steel core					Steel wires in cores
Numbers of strands	3	7	19	37	6	7	26	30	54	7
Area	2.961810	6.923620	18.6988000	36.2021000	5.923620	6.910890	25.3692000	29.2785000	52.6995000	...
Weight	3.038680	7.077370	19.3065000	37.8181000	6.077370	7.090260	26.6478000	30.7407000	55.3343000	7.04719
Resistance	0.337632	0.144433	0.0534794	0.027623	0.168826	0.144699	0.039418	0.034155	0.018976	...

LAY RATIOS OF ALUMINIUM CONDUCTORS GALVANIZED STEEL-REINFORCED

Number of Wires		Ratio of Aluminium wire Dia to steel wire diameter layer)	Lay ratios for steel core (6 Wires)		Outermost layer		Lay ratios for Aluminium Wire			
Alum.	Steel						Layer immediately beneath over most layer		Inter most layer or cach two wires 3 Aluminum wire layers	
Min	Max	Min	Max	Min	Max	Min	Max			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(1 0)	(11)
6	1	1	-	-	10	14	-	-	-	
6	7	3	13	28	10	14				
30	7	1	13	28	10	14	10	16	-	
42	7	1.8	13	28	10	14	10	16	10	17
54	7	1	13	28	10	14	10	16	10	17

COMPRESSED ALUMINIUM CONDUCTOR STEEL REINFORCED (CANADIAN STANDARD SIZED)

Code Word	Type	Aluminium Area		Complete of Conductor mm^2	Equiv. in copper mm^2	Diameter in mm		Ultimate breaking strength kg	D.C resistance at 20 °C Ω/km	Weight in kg/km			% of total weight		Standard length	Approx. weight of standard length
		AWG	mm^2			Complete Conductor	Steel Core			Alum.	Steel	Total	Alu. Km	Steel drum		
xx	100	8	8.37	9.81	5.26	3.68	1.33	340	3.423	33.8	22.9	10.9	67.9	32.1	8.35	280
xx	100	7	10.55	12.32	6.63	4.12	1.5	425	2.714	42.6	28.9	13.7	67.9	32.1	6.625	280
xx	100	6	13.3	15.48	8.37	4.62	1.68	530	2.154	53.7	36.5	17.2	67.9	32.1	5.255	280
xx	100	5	16.77	19.55	10.55	5.18	1.89	660	1.708	67.5	45.8	21.7	67.9	32.1	4.175	280
xx	100	4	21.15	24.71	13.3	5.79	2.12	630	1.354	85.3	57.9	27.4	67.9	32.1	3.31	280
xx	100	3	26.67	31.1	16.77	6.55	2.38	1.025	1.074	107.6	72.9	34.7	67.9	32.1	2.615	280
xx	100	2	33.62	39.22	21.15	7.34	2.67	1.265	0.8507	135.9	92.2	43.7	67.9	32.1	4.16	560
xx	100	1	42.41	49.48	26.67	8.26	3	1.585	0.6754	171.1	116.1	55	57.9	32.1	3.295	560
xx	100	1/0	53.49	62.39	33.62	9.25	3.37	1.94	0.5351	215.8	146.4	69.4	67.9	32.1	2.615	560
xx	100	2/0	67.43	78.64	42.41	10.41	3.78	2.425	0.4245	272	184.5	87.5	67.9	32.1	2.07	560
xx	100	3/0	85.01	99.22	53.49	11.68	4.25	3.03	0.3387	343	232.7	110.3	67.9	32.1	1.645	560
xx	100	4/0	107.2	125.1	67.43	13.11	4.77	3.82	0.2671	432.5	793.5	139	67.9	32.1	1.305	560
xx	150	8	8.37	11.16	5.26	3.91	1.89	500	3.423	44.6	22.9	21.7	51.2	48.8	4.175	185
xx	150	7	10.55	14.13	6.63	4.37	2.12	640	2.714	56.3	28.9	27A	51.2	48.8	3.31	185
xx	150	6	13.3	17.74	8.37	4.9	2.38	780	2.154	71.1	36.4	34.7	51.2	48.8	2.615	185
xx	150	5	16.77	22.39	10.55	5.49	2.67	980	1.708	89.4	45.8	43.6	51.2	48.8	4.16	370
xx	150	4	21.15	28.26	13.3	6.17	3	1.23	1.354	112.9	57.9	55	51.2	48.8	3.295	370
xx	150	3	26.67	35.55	16.77	6.91	3.37	1.505	1.074	142.3	72.9	69.4	51.2	48.8	2.615	370
xx	150	2	33.62	44.84	21.15	7.82	3.78	1.88	0.8507	179.8	92.2	87.36	51.2	48.8	2.07	370
xx	150	1	42.41	56.58	26.67	8.79	4.25	2.355	0.6754	226.4	116.1	110.3	51.2	48.8	1.645	370
xx	150	1/0	53.49	71.35	33.62	9.86	4.77	2.95	0.5351	285.4	146.4	139	51.2	48.8	1.305	370
xx	200	8	8.37	12.84	5.26	4.19	2.38	6.85	3.423	57.6	22.9	34.7	39.8	60.2	2.615	150
xx	200	7	10.55	16.19	6.63	4.67	2.67	865	2.714	72.5	28.9	42.6	39.8	60.2	4.16	300
xx	200	6	13.30	20.39	8.37	5.28	3	1.09	2.154	91.5	36.5	55	39.8	60.2	3.295	300
xx	200	5	16.77	25.68	10.55	5.92	3.37	1.33	1.78	115.2	45.9	69.3	39.8	60.2	2.615	300
xx	200	4	21.15	32.39	13.3	6.71	3.78	1.67	1.354	145.4	57.9	87.5	39.8	60.2	2.07	300
xx	200	3	26.67	40.84	16.77	7.47	4.25	2.1	1.074	183.2	72.9	110.3	39.8	60.2	1.645	300
xx	200	2	33.62	51.48	21.15	8.41	4.77	2.625	0.8507	231	92	139	39.8	60.2	1.305	300

1. The galvanized steel and round aluminium strands used to manufacture these conductors meet the requirements of CS Specifications C49 - 1965. 2. Comp. ACSR Types 100 150 and 200 have an ultimate strength equal to 100% 150% and 200% respectively of the equal sizes of ACSR 6/1. 3. Weight tolerance is ± 2% of the nominal for the complete conductor and ± 4% for the aluminium, 4. Normal cable spans are supplied with a length tolerance of ± 10%, 5. 10% of a purchase order may be supplied in manufactured lengths, none of which will be shorter than half of the standard minimum length.

COMPRESSED ALL ALUMINIUM CONDUCTOR (CANADIAN STANDARD SIZES)

Toad	6	13.3	8.37	7	4.3	265	2.149	36.3
Ozard	5	16.77	10.55	7	4.8	335	1.704	45.8
Dragon	4	21.15	133	7	5.4	415	1.351	57.7
Lizard	3	26.67	16.77	7	6.1	515	1.072	72.8
Moloch	2	33.52	21.15	7	6.9	635	0.85	91.8
Monitor	1	42.41	26.67	7	7.6	775	0.674	115.8
Tuatara	1/0	53.49	33.62	7	8.6	940	0.534	146.1
Alligator	2/0	67.43	42.41	7	9.7	1.185	0.424	184.2
Crocodile	3/0	85.01	53.49	7	10.9	1.435	0.336	232.3
Salamander	4/0	107.2	67.43	7	12.2	1.81	0.267	292.9
Komodo	266.8	135.2	85.01	18	13.8	2.42	0.213	370.5
Tadpole	300	152	95.6	18	14.6	2.67	0.189	417.4
Basillisk	336.4	170.5	107.2	18	15.5	2.995	0.168	467.3
Hatteria	397.5	201.4	126.7	18	16.9	3.47	0.142	553
Chuckwalla	477	241.7	152	18	18.5	4.08	0.119	663.5

ALL ALLOY ALUMINIUM CONDUCTOR (FRENCH STANDARD SIZES)

Characteristics

Modulus of elasticity 6120 kg/ mm^2
Coefficient of expansion 23 x 10^4
Coefficient of variation in Electrical Resistance per° C 0.0036

Normal area mm^2	Composition maximum mm	Exterior diameter mm	Approximately weight Kg/Km	Ultimate strength Kg	Electrical Resistance at 20 °C Ω/km
22	7x 2.00	6	60.2	725	1.5
34.4	7x 2.50	7.5	94	1.125	0.958
43.1	7x 2.80	8.4	118	1.415	0.769
54.6	7x 3.15	9.45	149.2	1.79	0.603
75.5	19x 2.25	11.25	207.7	2.475	0.438
93.3	19x 2.50	12.5	256.3	3.06	0.357
117	19x 2.80	14	321.6	3.84	0.283
148	19x 3.15	15.75	407	4.86	0.224
181	37x 2.50	17.5	500	5.96	0.183
228	37x 2.80	19.6	627.5	7.485	0.146
288	37x 3.15	22.05	794.1	9.465	0.115
366	37x 3.55	24.85	1008.6	12.02	0.0905
475	61x 3.15	28.35	1311.9	15.605	0.0706
570	61x 3.45	31.5	1.574	18.725	0.0583
604	61x 3.55	31.95	1.665	19.825	0.055

ALUMINIUM ALLOY CONDUCTOR 6201 T. 81 (ASTM STANDARD SIZES)

Code Word	Section		Composition		Exterior Cable	Cable weight	Ultimate Strength	Resistance at		Intensity	ACSR Cable of equal Diameter		Equivalent ACSR Cable Diameter	
								20° C	50° C		MCM AWG	Standing	MCM AWG	mm
	MCM	mm^2	No.	mm	mm	Kg/km	Kg	W /kg		Amps				
Akron	30.58	15.49	7	1.68	5.04	42	477	2.161	2.385	100	6	6/1	25.9	13
Alton	48.69	24.67	7	2.12	6.36	68	760	1.357	1.498	130	4	6/1	41.2	20.87
Ames	77,47	39.25	7	2.57	8.01	108	1.21	2.853	0.942	180	2	6/1	65.6	33.24
Azusa	123.3	52.47	7	3.37	10.11	172	1.925	0.536	0.592	240	1/0	6/1	104.4	52.9
Anahim	155.4	78.74	7	3.78	11.34	217	2.326	0.425	0.469	280	2/0	6/1	131.6	66.68
Anherst	195.7	99.16	7	4.25	12.75	273	2.927	0.337	0.373	325	3/0	6/1	165.7	83.96
Alliance	246.9	125.1	7	4.77	14.31	345	3.695	0.267	0.296	380	4/0	6/1	209.1	105.95
Butte	312.8	158.5	19	3.25	16.25	436	4.626	0.211	0.233	440	266.8	26/7	264.9	134.22
Canton	394.5	199	19	3.66	18.13	551	5.594	0.167	0.185	510	336.4	26/7	334.1	169.28
Carlo	465.4	235.82	19	3.97	19.85	650	6.597	0.142	0.157	570	397.5	26/7	394.1	199.7
Dairen	559.5	283.5	19	4.35	21.75	781	7.93	0.118	0.131	630	477	26/7	473.8	240.07
Elgin	652.4	330.57	19	4.7	23.15	1911	9.247	0.101	0.112	710	556.5	26/7	552.4	280
Flint	740.8	375.36	37	3.95	25.13	1.034	10.503	0.0891	0.0967	770	636	26/7	627.3	371.8
Greeley	927.2	469.81	37	4.02	28.14	1.295	13.145	0.0712	0.0801	890	795	26/7	785.1	397,8

The above cables are manufactured in accordance with ASTM Standards B 398-67 and 13399-69a.
Resistance value is based on a minimum conductivity of 52.5% IACS.
Carrying capacity is calculated for an increase of 50°C over an ambient temperature of 25° C a wind velocity of 0.60 meters/ second and a co-efficient of emissivity of 0.5.

ALL ALUMINIUM CONDUCTOR -AAC (FRENCH STANDARD SIZES)

Section Nominal mm^3	Composition N°x mm	Exterior diameter mm	Cable weight Kg/Km	Ultimate Strength	Electrical resistance at 20° C/Km	Module of elasticity bars	Coefficient of line expansion x 10°
27.8	7x 2.25	6.75	76.2	478	1.03	6	23
34.4	In 2.50	7.5	94.1	576	0.833	6	23
43.1	7x2.80	8.4	118	706	0.664	6	23
54.6	7x 3.15	9.45	149.4	873	0.527	6	23
75.5	19x 2.25	11.25	207.9	1294	0.381	5.7	23
93.3	19x 2.50	12.5	256.6	1563	0.308	5.07	23
117	19x 2.80	14	821.9	1917	0.246	5.7	23
148	19x 3.15	15.75	407.4	2371	0.194	5.7	23
188	19x 3.55	17.75	517.4	2923	0.153	5.7	23
228	37x 2.80	19.6	628.2	3733	0.126	5.7	23
288	37x 3.15	22.05	795	4617	0.1	5.7	23
366	37x 3.55	24.85	1009.7	5694	0.0787	5.7	23
475	61 x 3.15	28.35	1313.4	7206	0.0608	5.5	23
604	61x 3.51	31.95	1668.1	8895	0.0479	5.5	23

NOTE : (1) daN = 1.02 kg of force; (2) 1hbar = 1.02kg/spsnm.;
(3) These cables are manufactured according to the Standard C34-120

ALL ALUMINIUM CONDUCTOR - AAC (DIN STANDARD SIZES)

Section Nominal	Theoretical area mm³	Composition N° x mm	Cable diameter Kg/Km	Cable weight	Approximately ultimate strength Kgs.f	Constant load capacity Amp.
25	24.25	7x 2.1	6.3	67	425	145
35	34.36	7x 2.5	7.5	94	585	180
50	49.48	7x 3.0	9	135	810	225
50	48.36	190 1.8	9	133	860	225
70	65.82	19x 2.1	10.5	181	1150	270
95	93.27	19x 2.5	12.5	256	1595	340
120	117	19x 2.8	14	322	1910	390
150	147.1	37x2.25	15.7	406	2570	455
185	181.6	37x 2.5	17.5	501	3105	520
240	242.5	61x 2.25	20.2	670	4015	625
300	299.4	61 x 2.5	222.5	827	4850	710
400	400.1	61x 2.89	28	1105	6190	855
500	499.8	61x 3.23	29.1	1381	7670	990
625	626.2	91x 2.96	32.6	1733	9610	1140
800	802.1	91x 3.35	36.8	2219	12055	1340
1000	999.7	91. 3.74	41.1	2766	14845	1540

Theoretical values valid up to 60Hz fora wind velocity of 0.6 m/sec. and solar action for an initial temperature of 3.5°C and an ultimate cable temperature of 80°C. In the case of unusual placement without air movement, these values will be reduced on an average of 30% approximately.

ALL ALUMINIUM ALLOY CONDUCTOR (AAAC) DIN 48201/6

Cross Section		Construction						
mm²	mm²		mm	mm	kg/km	kN	Ω/km	A
16	15.89	7	1.70	5.1	43	4.44	2.090	105
25	24.25	7	2.10	6.3	66	6.77	1.370	135
35	34.36	7	2.50	7.5	94	9.6	0.967	170
50	49.48	7	3.00	9.0	135	13.82	0.671	210
50	48.35	19	1.80	9.0	133	13.5	0.690	210
70	65.81	19	2.10	10.5	181	18.38	0.507	255
95	93.27	19	2.50	12.5	256	26.05	0.358	320
120	116.99	19	2.80	14.0	322	32.68	0.285	365
150	147.11	37	2.25	15.8	406	41,09	0.227	425
185	181.62	37	2.50	17.5	500	50.73	0.184	490
240	242.54	61	2.25	20.3	670	67.47	0.138	585
300	299.43	61	2.50	22.5	827	83.63	0.112	670
400	400.14	61	2.89	26.0	1,104	111.76	0.084	810
500	499.83	61	3.23	29.1	1,379	139.6	0.067	930
625	626.20	91	2.96	32.6	1,732	174.9	0.054	1075
800	802.09	91	3.35	36.9	2.218	224.02	0.042	1255

ALUMINIUM CONDUCTORS (AAC)
ASTM B 231 CSA-Standard C 49.3 -1977

Code Word	Cross section (Actual)	No. of Wires	Wire Diameter	Complete Conductor diameter	Conductor weight approx.	Calculated Breaking load	Resistance at 20°C
	mm2		mm	mm	kg/km	KN	Ω/Km
PEACH BELL	13.21	7	1.55	4.65	36.5	2.47	95
ROSE	21.12	7	1.96	5.88	58.2	3.94	130
IRIS	33.54	7	2.47	7.41	92.5	5.95	175
ANSY	42.49	7	2.78	8.34	117.1	7.01	200
POPPY	53.52	7	3.12	9.36	147.6	8.73	235
ASTER	67.35	7	3.50	10.50	185.7	10.99	270
PHLOX	84.91	7	3.93	11.79	234.1	13.45	315
OXLIP	106.9	7	4.41	13.23	294.7	16.92	365
SNEEZEWORT	126.7	7	4.80	14.40	348.5	20.06	405
VALERIAN	126.4	19	2.91	14.55	349.3	20.57	405
DAISY	135.3	7	4.96	14.80	372.8	21.43	420
LAUREL	135.2	19	3.01	15.05	373.0	22.00	425
PEONY	151.9	19	3.19	15.95	418.8	24.02	455
TULIP	170.5	19	3.38	16.90	470.1	26.97	495
DAFFODIL	177.6	19	3.45	17.25	489.7	28.08	506
CANNA	202.1	19	3.68	18.40	557.2	31.95	550
GOLDENTFT	228.1	19	3.91	19.55	628.9	35.00	545
COSMOS	241.2	19	4.02	20.10	665.0	37.01	615
SYRINGA	241.0	37	2.88	20.16	664.5	38.38	615
ZINNIA	253.3	19	4.12	20.60	698.4	38.87	635
HYACINTH	252.9	37	2.95	20.65	697.3	40.27	635
DAHLIA	282.4	19	4.35	21.75	778.6	43.33	680
MISTLETOE	281.1	37	3.11	21.77	775.0	43.99	680
MEADOWSWEET	303.2	37	3.23	22.61	835.9	46.91	715
ORCHID	322.2	37	3.33	23.31	888.3	49.84	745
HEUCHERA	330.0	37	3.37	23.59	909.8	51.05	755
VERBENA	354.0	37	3.49	24.43	976.0	54.76	790
FLAG	354.5	61	2.72	24.48	977.4	57.43	790
VIOLET	362.1	37	3.53	24.71	998.3	56.02	800
NSTURTIUM	362,3	61	2.75	24.75	998.9	58.69	800
PETUNIA	330.8	37	3.62	25.34	1050	58.91	825
CATTAIL	381.0	61	2.82	25.38	1050	60.01	825
ARBUTUS	402.1	37	3.72	26.04	1109	62.20	855
LILAC	402.9	61	2.90	26.10	1111	63.46	855
COCKSCOMB	455.7	37	3.96	27.72	1256	67.67	925
SNAODRAGON	457.4	61	3.09	27.81	1261	69.98	925
MAGNOLIA	483.4	37	4.08	28.56	1333	72.58	960
GOLDENROD	484.5	61	3.18	28.62	1336	74.13	960
HAWKWEED	507.7	37	4.18	29.26	1400	76.23	990
CAMELLIA	506.0	61	3.25	29.25	1395	77.42	990
BLUEBELL	524.9	37	4.25	29.75	1447	78.81	1015
LARKSKPUR	524.9	61	3.31	29.79	1447	80.31	1015
MARIGOLD	563.6	61	3.43	30.87	1554	86.23	1040
HAWTHORN	603.8	61	3.55	31.95	1665	92.38	1085
NARCISSUS	645.3	61	3.67	33.03	1779	98.73	1130
COLUMBINE	684.5	61	3.78	34.02	1887	104,7	1175
CARNATION	766.6	61	3.89	35.01	1999	107.7	1220
GLADIOLUS	725.0	61	4.00	36.00	2114	113.8	1265
COREOPSIS	805.4	61	4.10	36.90	2221	119.6	1305
JESSAMINE	885.8	61	4.30	38.70	2442	131.5	1385
COWSLIP	1010	91	3.76	41.36	2785	152.8	1500
AGEBRUSH	1138	91	3.99	43.89	3168	167.1	1600
LUPINE	1267	91	4.21	46.31	3527	186.1	1700
BITTERROT	1396	91	4.42	48.62	3887	205.0	1795
TRILLIUM	1517	127	3.90	50.70	4223	222.8	1885
BLUEBONNET	1776	127	4.22	54.86	4993	260.8	2035

ALUMINIUM CONDUCTORS STEEL REINFORCED (ACSR)
BS 215 Part 2

Code Word	Total Cross Section	Complete Conductor Diameter	Conductor Weight Approx.	Calculated Breaking Load.	Current Carrying Capacity	Alu.	Steel	Construction Steel	Section Steel	Construction Aluminium	Section Aluminium
	mm^2	mm	kg/km	kN	A	%	%	mm	mm^2	mm	mm^2
MOLE	12.37	4.50	42.9	4.26	80	67.9	32.1	1X1.50	1.77	6X1.50	10.60
SQUIRREL	24.48	6.33	84.8	8.23	125	67.9	32.1	1X2.11	3.50	6X2.11	20.98
GOPHER	30.62	7.08	106.0	10.03	145	68.0	32.0	1X2.36	4.37	6X2.36	26.25
WEASEL	36.88	7.77	127.7	11.94	165	68.0	32.0	1X2.59	5.27	6X2.59	31.61
FOX	42.79	8.37	148.1	13.85	180	68.0	32.0	1X2.79	6.11	6X2.79	36.68
FERRET	49.48	9.00	171.4	15.81	195	68.0	32.0	1X3.00	7.07	6X3.00	42.41
RABBIT	61.69	10.05	213.6	19.12	225	68.0	32.0	1X3.35	8.81	6X3.35	52.88
MINK	73.64	10.98	255.0	22.12	250	68.0	32.0	1X3.66	10.52	6X3.66	63.12
BEAVER	87.52	11.97	303.1	25.92	280	68.0	32.0	1X3.99	12.50	6X3.99	75.02
RACCOON	91.96	12.27	320.6	27.24	290	67.5	32.5	1X4.09	55.98	6X4.09	78.82
OTTER	97.90	12.66	339.0	29.00	305	68.0	32.0	1X4.22	13.98	6X4.22	83.92
SKUNK	100.10	12.95	463.6	56.24	250	37.5	62.5	7X2.59	36.88	12X2.59	63.22
CAT	111.30	13.50	385.3	31.57	325	68.0	32.0	1X4.50	15.87	6X4.50	95.43
HORSE	116.20	13.95	536.3	66.32	280	37.6	62.4	7X2.79	42.84	12X2.79	73.36
DOG	118.60	14.15	395.6	33.74	345	72.9	27.1	7X1.57	18.60	6X4.72	105.00
HARE	122.50	14.16	424.3	36.29	345	68.0	32.0	1X4.72	17.50	6X4.72	105.00
HYENA	126.50	14.57	452.2	42.57	345	64.6	35.6	7X1.93	20.50	7X4.39	106.00
LEOPARD	148.20	15.81	493.4	41.94	400	73.1	26.9	7X1.75	16.80	6X5.28	131.40
COYOTE	151.50	15.86	519.6	47.46	430	69.6	30.4	7X1.90	19.80	26X2.54	131.70
TIGER	161.90	16.52	605.8	60.30	435	59.5	40.5	7X2.36	30.70	30X2.36	131.20
DINGO	167.50	16.75	506.0	35.70	490	86.1	13.9	1X3.35	8.80	18X3.35	158.70
CARACAL	194.50	18.05	587.0	41.10	540	86.2	13.8	1X3.61	10.20	18X3.61	184.30
WOLF	194.90	18.13	726.8	7 1 .69	490	59.7	40.3	7X2.59	36.80	30X2.59	158.10
JAGUAR	222.30	19.30	671.0	46.55	590	86.2	13.8	1X3.86	11.70	18X3.86	210.60
LYNX	226.20	19.53	844.0	83.29	540	59.7	40.3	7X2.79	42.80	30X2.79	183.40
PANTHER	261.50	21.00	975.4	95.22	595	59.7	40.3	7X3.00	49.40	30X3.00	212.10
LION	293.90	22.26	1097.0	103.90	640	59.7	40.3	7 X3.1 8	55.60	30X3.18	238.30
BEAR	326.10	23.45	1217.0	115.20	685	59.7	40.3	7X3.30	61.70	30X3.35	264.40
GOAT	400.00	25.97	1493.0	136.30	780	59.7	40.3	7X3.71	75.70	30X3.71	324.3
ANTELOPF	422.60	26.73	1415.0	119.20	845	72.6	27.4	7X2.97	48.5	54X2.97	374.10
BISON	431.20	27.00	1444.0	121.60	850	72.6	27.4	7X3.00	49.50	54X3.00	381.7
SHEEP	462.60	27.93	1726.0	155.80	860	59.7	40.3	7X3.99	87.50	30X3.99	375.1
ZEBRA	484.50	28.62	1622.000	132.50	920	72.6	27.4	7 X3.1 8	55.60	54.3.18	428.9
DEER	529.80	29.89	1977.1	178.50	940	59.7	40.3	7X4.27	100.40	30X4.27	429.6
CAMEL	537.70	30.15	1801.0	147.10	985	72.6	27.4	7X3.35	61.70	54X3.35	476
ELK	588.50	31.50	2196.0	198.30	985	59.7	40.3	7X4.50	' 11.40	30X4.50	477.1
MOOSE	597.00	31.77	1999.0	163.30	1030	72.6	27.4	7X3.53	68.50	54X3.53	528.5

ALL ALUMINIUM ALLOY CONDUCTORS (AAAC)

ASTM B 399

BS 3242: 1970

Code Word	CROSS SECTION (Nominal)	No. of Wires	Wire Diameter	Complete Conductor diameter	Conductor weight approx.	Calculated Breaking load	Resistance at 20°C
	mm²	mm²		mm	mm	kg/km	kN
-	10	11.88	7	1.47	4.41	32.8	3.76
AKRON		15.52	7	1.68	5.04	42.8	4.92
BOX	15	18.82	7	1.85	5.55	51.9	5.96
ACACIA	20	23.79	7	2.08	6.24	65.6	7.54
ALTON		24.71	7	2.12	6.36	68.1	7.83
ALMOND	25	30.10	7	2.34	7.02	83.0	9.53
CEDAR	30	35.47	7	2.54	7.62	97.8	11.20
MES		39.19	7	2.67	8.01	108.0	12.42
-	35	42.18	7	2.77	8.31	116.3	13.40
FIR	40	47.84	7	2.95	8.85	131.9	15.10
HAZEL	50	59.87	7	3.30	9.90	165.1	20.00
AZUZA		62.44	7	3.37	10.11	172.2	19.78
PINE	60	71.65	7	3.61	10.83	197.5	22.70
ANAHEIM		78.55	7	3.78	11.34	216.6	23.75
	79	84.05	7	3.91	11.73	231.7	25.40
WILLOW	75	89.73	7	4.04	12.12	247.4	27.10
-	80	96.52	7	4.19	12.57	266.1	29.20
AMHERST		99.30	7	4.25	12.75	273.8	30.03
	90	108.40	7	4.44	13.32	298.9	32.80
OAK	100	118.90	7	4.65	13.95	327.8	36.00
ALLIANCE	100	125.10	7	4.7	14.31	344.9	37.83
MULBERRY		150.90	19	3.18	15.90	416.0	46.3
BUTTE	125	158.60	19	3.26	16.30	437.3	48.67
ASH	150	180.70	19	3.48	17.40	498.2	52.90
CANTON	150	199.90	19	3.66	18.30	551.1	58.56
ELM		211.00	19	3.76	18.80	581.7	61.8
CAIRO	175	236.40	19	3.98	19.90	651.8	69.25
POPLAR		239.40	37	2.87	20.09	660.0	71.90
-	200	270.30	37	3.05	21.35	745.2	81.20
DARIEN	225	283.70	19	4.36	21.80	782.2	83.11
SYCAMORE		2301.30	37	3.22	22.54	830.7	90.50
ELGIN	250	331.00	19	4.71	23.55	912.6	96.97
UPAS	300	362.10	37	3.53	24.71	998.3	103.80
FLINT		374.50	37	3.59	25.13	1033.0	107.40
-	350	421.80	37	3.81	26.67	1163.0	120.90
GREELEY		469.60	37	4.02	28.14	1295.0	134.6
YEW	400	479.00	37	4.06	28.42	1321.0	137.3

AWG/MCM versus metric conductor sizes

AWG	mm^2	AWG	mm^2	AWG	mm^2
2000 MCM	994.0	4/0	107.2	15	1.65
1750 MCM	870.0	3/0	85.0	16	1.30
1500 MCM	745.0	2/0	67.4	17	1.039
1250 MCM	621.0	1/0	53.5	18	0.821
1000 MCM	506.0	1	42.4	19	0.654
900 MCM	457.4	2	33.7	20	0.517
800 MCM	405.7	3	26.7	21	0.411
750 MCM	381.0	4	21.2	22	0.324
700 MCM	354.5	5	16.7	23	0.259
650 MCM	328.9	6	13.3	24	0.205
600 MCM	303.2	7	10.5	25	0.162
550 MCM	279.3	8	8.36	26	0.128
500 MCM	252.9	9	6.63	27	0.107
450 MCM	227.8	10	5.26	28	0.080
400 MCM	203.2	11	4.17	29	0.065
350 MCM	177.6	12	3.30	30	0.05
300 MCM	151.8	13	2.62		
250 MCM	126.4	14	2.08		

ALUMINIUM CONDUCTORS STEEL REINFORCED (ACSR) - DIN 48204

Nominal cross Section Al./St	Total Cross Section	Conductor Diameter	Conductor Weight Approx.	Calc. Breaking Load.	Elec Resistance at 20°C	Steel Construction Steel	Steel Cross Section	Alu. Constru-ction	Alu. Cross Section	Alu. Portion	Portion
mm^2	mm^2	mm	Kg/km	kN	Ω/km	mm	mm^2	mm	mm^2	%	%
16/2.5	17.8	5.4	62	5.81	1.871	1X1.80	2.54	6X1.80	15.27	67.6	32.4
25/4	27.8	6.8	97	9.02	1.198	1x2.25	3.98	6X2.25	23.86	67.6	32.4
35/6	40.1	8.1	140	12.70	0.835	1x2.70	5.73	6x2.70	34.35	67.4	32.6
44/32	75.7	11.2	373	45.46	0.694	7x2.40	31.67	14X2.00	43.98	32.4	67.6
50/8	56.3	9.6	196	17.18	0.595	1X3.20	8.04	6X3.20	48.25	67.6	32.4
50/30	81	11.7	378	44.28	0.558	7X2.33	29.85	12X2.33	51.17	37.2	62.8
70/12	81.3	11.7	284	26.31	0.413	7X1.44	11.4	26X1.85	69.89	67.6	32.4
94/22	116.2	14.0	432	44.10	0.307	7X2.00	22.00	30X2.00	94.20	59.9	40.1
95/15	109.7	13.6	383	35.17	0.306	7X1.67	15.33	26X2.15	94.35	67.8	32.2
95/34	131.1	14.9	537	58.10	0.299	7X2.50	34.36	36X1.85	96.77	49.5	50.5
95/55	152.8	16.0	714	80.20	0.297	7X3.20	56.30	12X3.20	96.51	37.1	62.9
105/75	181.2	17.5	899	106.69	0.271	19X2.25	75.55	14X3.10	105.67	32.3	67.6
120/20	141.4	15.5	494	44.94	0.243	7X1.90	19.85	26X2.44	121.57	67.6	32.4
120/42	160.4	16.5	654	70.10	0.245	7X2.75	41.58	36X2.05	118.82	49.9	50.1
120/70	193.4	18.0	904	98.16	0.241	7X3.60	71.25	12X3.60	122.15	37.1	62.9
125/30	157.8	16.3	590	57.86	0.226	7X2.33	29.85	30X2.33	127.92	59.5	40.5
150/25	173.1	17.1	604	54.37	0.194	7X2.10	24.25	26X2.70	148.86	67.7	32.3
150/53	202.4	18.5	827	86.05	0.193	7X3.10	52.83	36X2.30	149.57	49.9	50.1
170/40	211.9	18.9	794	77.01	0.167	7X2.70	40.08	30X2.70	171.77	59.4	40.6
185/30	213.6	19.0	744	66.28	0.156	7X2.33	29.85	26X3.00	183.78	67.8	32.2
210/35	243.2	20.3	850	74.90	0.138	7X2.49	34.09	26X3.20	209.10	67.6	32.4
210/50	261.5	21.0	981	93.90	1.136	7X3.00	49.48	30X3.00	212.06	59.4	40.6
240/40	282.5	21.9	987	86.40	0.119	7X2.68	39.49	26X3.45	243.05	76.6	32.4
257/60	316.5	23.1	1177	109.95	0.113	7X3.30	59.87	30X3.30	256.59	59.9	40.1
265/35	297.8	22.4	1002	83.05	0.109	7X2.49	34.09	24X3.74	263.56	72.3	27.7
300/50	353.7	24.5	1236	107.00	0.095	7X3.00	49.48	26X3.86	304.26	67.6	32.4
305/40	344.1	24.1	1155	99.30	0.094	7X2.68	39.49	54X2.68	304.62	72.4	27.6
340/30	369.1	25.0	1174	92.56	0.086	7X2.33	29.85	48X3.00	339.29	79.4	20.6
340/110	450	27.7	1799	187.60	0.085	19X2.70	108.79	78X2.36	341.20	52.1	47.9
380/50	431.2	27.0	1448	120.91	0.075	7X3.00	49.48	54X3.00	381.70	72.4	27.6
385/35	420.1	26.7	1336	104.31	0.074	7X2.49	34.09	48X3.20	386.04	79.4	20.6
435/55	490.6	28.8	1647	136.27	0.066	7X3.20	56.30	54X3.20	434.29	72.4	27.6
450/40	488.2	28.7	1553	120.19	0.064	7X2.68	39.49	48X3.45	448.71	79.4	20.8
490/56	553.8	30.6	1860	152.85	0.059	7X3.40	63.55	54X3.40	490.28	72.4	27.6
495/35	528.4	29.9	1636	120.31	0.058	7X2.49	34.09	45X3.74	494.36	83.0	17.0
510/45	555.8	30.7	1770	134.33	0.056	7X2.87	45.28	48X3.68	510.54	79.2	20.8
550/70	620.9	32.4	2085	167.42	0.052	7X3.60	71.25	54X3.60	549.65	72.4	27.6
560/50	611.2	32.2	1943	146.28	0.051	7X3.00	49.48	48X3.86	561.7	79.4	20.6
570/40	610.7	32.2	1889	137.98	0.050	7X2.68	39.49	45X4.02	571.61	83.0	17.0
650/45	698.8	34.4	2163	155.52	0.044	7X2.87	45.28	45X4.30	653.49	83.0	17.0
680/85	764.5	36.0	2564	209.99	0.042	19X2.40	85.95	54X4.00	678.58	72.7	27.3
1045/45	1090.9	43.0	3249	217.87	0.027	7X2.87	45.28	72X4.30	1045.58	88.4	11.6

ALUMINIUM CONDUCTORS STEEL REINFORCED (ACSR) CSA -C49,1

Code word	Total Cross Section	complete conductor diameter	Conductor Weight Approx.	Calc. Breaking Load.	Current carrying capacity	Construction Steel	Section Steel	Constru- ction on Aluminium	Section Alu.	Alu.	Steel
	mm^2	mm	Kg/km	kN	A	mm	mm^2	mm	mm^2	%	%
TURKEY	15.52	5.04	53.7	5.28	95	1X1.68	2.22	6X1.68	13.30	68.0	32.0
TRUSH	19.55	5.67	67.6	6.47		1X1.89	2.80	6X1.89	16.77	68.'	31.9
SWAN	24.71	6.36	85.6	8.39	130	1X2.12	3.61	6X2.12	21.1	67.7	32.3
SWANATE	26.47	6.53	99.6	10.52	130	1X2.61	5.35	7X1.96	21.12	58.2	41.8
SWALLOW	31.1	7.14	107.6	10.05		1X2.38	4.44	6X2.38	26.67	68.1	31.9
SPARROW	39.19	8.01	135.8	12.68	175	1X2.67	5.60	6X2.67	33.59	67.9	32.1
SPARATE	42.09	3.24	158.5	16.13	175	1X3.30	8.55	7X2.47	33.54	58.1	41.9
ROBIN	49.48	9	171.4	15.81	200	1X3.00	7.07	6X3.00	42.41	68	32
RAVEN	62.44	13.11	216.2	19.35	230	1X3.37	8.92	6X3.37	53.52	68	32
QUAIL	78.55	11.34	271.8	23.59	265	1X3.78	11.22	6X3.78	67.33	68	32
PIGEON	99.30	12.75	343.8	29.41	310	1X4.25	14.18	6X4.25	85.12	68	32
PENGUIN	125.10	14.31	433.4	37.09	350	1X4.77	17.90	6X4.77	107.20	67.9	32.1
WAXWING	142.50	15.45	430.6	30.27	430	1x3.09	7.50	'13X3.09	135.00	86.1	13.9
OWL	153.00	16.09	510.6	42.93	410	7X1.79	17.60	6X5.36	135.40	72.8	27.2
PARTRIDGE	156.90	16.28	545.6	50.25	440	7X2.00	22.00	26X2.57	134.90	67.9	32.1
OSTRICH	176.70	17.28	12.7	56.15		7X2.12	24.70	26X2.73	152.00	68.1	31.9
MERLIN	179.70	17.35	543.2	38.22	500	1X3.47	9.50	18X3.47	170.20	86.0	14.0
LINNET	198.40	81.31	698.8	62.73	510	7X2.25	27.80	26X2.89	170.60	67.9	32.1
ORIOLE	210.30	18.83	784.7	77.45	515	7X2.69	39.80	30X2.69	170.50	59.7	40.3
CHICKADEE	212.10	18.85	640.5	44.34	555	1X3.77	11.20	18X3.77	200.90	86.1	13.9
BRANT	227.70	19.62	762.4	64.70	565	7X2.18	26.10	24X3.27	201.60	72.6	27.4
IBIS	234.10	19.8	813.9	72.13	570	7X2.44	32.80	26X3.14	201.30	67.9	32.1
LARK	247.80	20 4	924.7	90.33	575	7X2.92	46.90	30X2.92	200.90	59.7	40.3
PELICAN	255.80	0.7	773.0	52.34	625	1X4.14	13.15	18X4.14	242.30	36.1	13.9
FLICKER	273.00	1.49	914.7	76.78	635	7X2.39	31.40	24X3.58	241.60	72.5	27.5
HAWK	281.10	21.8	977.9	86.73	640	7X2.68	39.50	26X3.44	241.60	67.8	32.2
HEN	297.60	22.4	1110.4	"05.20	645	7X3.20	56.30	30X3.20	241.30	59.8	40.2
OSPREY	298.20	22.35	901.0	60.98	690	1X4.47	15.70	18X4.47	282.50	36.1	13.9
HERON	312.40	22.96	1162.0	108.68		7X3.28	59.14	30X3.28	253.30	59.9	40.1
PARAKEET	318.90	23.22	1068.0	88.29	700	7X2.58	36.60	24X3.87	282.30	72.6	7.4
DOVE	328.50	23.55	1142.0	101.10	710	7X2.89	45.90	26X3.72	282.60	68	32
SWIFT	332.00	23.66	960.5	60.68	745	1X3.38	9.00	36X3.38	323.00	12.3	7.7
KINGBIRD	340.90	23.9	1030.0	69.67	750	1X4.78	17.90	18X4.78	323.00	86.1	13.9
-	343.10	25.38	1006.1	65.79	760	3X2.25	11.90	18X4.84	331.20	10.4	9.6
PEACOCK	345.90	24.19	1159.0	95.80	740	7X2.69	39.80	24X4.03	306.10	72.5	27.5
DUCK	346.40	24.21	1158.0	99.99		7X2.69	39.78	54X3.69	306.60	72.7	27.3
EAGLE	347.90	24.22	1298.0	122.90	710	7X3.46	65.80	30X3.46	282.10	a9.7	40.3
SQUAB	355.60	24.51	1236.0	108.10	745	7X3.01	49.80	26X3.87	305.80	67.9	32.1
GOOSE	364.00	24.84	1218.0	105.32		7X2.76	41.88	54X2.76	322.30	72.7	27.3

Code word	Total Cross Section	complete conductor diameter	Conductor Weight Approx.	Calc. Breaking Load.	Current carrying capacity	Construction Steel	Section Steel	Constru-ction on Aluminium	Section Alu.	Alu.	Steel
	mm^2	mm	Kg/km	kN	A	mm	mm^2	mm	mm^2	%	%
ROCK	365.00	24.84	1223.0	101.10	765	7X2.76	41.90	24X4.14	323.10	72.6	27.4
GROSBEAK	374.30	25.15	1302.0	111.90	775	7X3.09	52.50	26X3.97	321.80	67.9	32.1
TEAL	376.60	25.24	1397.0	133.30	750	19X2.16	69.60	30X3.61	307.00	60.4	39.6
FLAMINGO	381.00	24.21	1276.0	105.50	790	7X2.82	43.70	24X4.23	337.30	72.6	27.4
GULL	381.30	25.38	1276.0	78.66		7X2.82	43.72	54X2.82	337.80	72.7	27.3
GANNET	393.20	25.76	1366.0	117.30	795	7X3.16	54.90	26.4.07	338.30	68.0	32.0
EGRET	396.10	25.90	1471.0	140.50	775	19X2.22	73.50	30X3.70	322.60	60.2	39.8
CROW	409.50	26.28	1370.0	116.88		7X2.48	86.87	54X2.92	262.50	52.6	47.4
COOT	413.10	26.39	1195.0	74.75	860	1X3.77	11.20	36X3.77	401.90	92.4	7.6
STARLING	421.00	26.68	1465.0	125.90	835	7X3.28	59.10	26X4.21	361.90	67.8	32.2
TERN	431.60	27.03	1336.0	97.43	875	7X2.25	27.80	45X3.38	403.80	8.30	17.0
REDWING	444.50	27.43	1651.0	153.70	840	19X2.35	82.40	30X3.92	362.10	60.2	39.8
CUCKOO	454.50	27.74	1523.0	123.90	885	7X3.08	52.20	24X4.62	402.30	72.5	27.5
CONDOR	454.50	27.72	1523.0	124.40	885	7X3.08	52.20	54X3.08	402.30	72.5	27.5
DRAKE	468.00	28.11	1626.0	139.60	890	7X3.45	65.40	26X4.44	402.60	68.0	32.0
RUDDY	487.20	28.74	1510.0	109.40	945	7X2.40	31.70	14X1.59	455.50	82.8	17.2
MALLARD	495.60	28.96	1840.0	171.20	900	19X2.48	91.80	30X4.11	403.80	60.3	39.7
CATBIRD	498.10	28.98	1441.0	87.93	970	1X4.14	13.50	36X4.14	484.60	92.4	7.6
CRANE	500.60	29.11	1674.0	139.54		7X3.23	57.36	54X3.23	443.10	72.7	27.3
CANARY	515.30	29.52	1725.0	140.90	955	7X3.78	59.10	54X3.78	456.20	72.6	27.4
RAIL	517.40	29.61	1603.0	116.10	980	7X2.47	33.60	45X3.70	483.80	82.9	17.1
CARDINAL	547.30	30.42	1832.0	149.70	995	7X3.38	62.80	54X3.38	484.50	72.6	27.4
ORTOLAN	560.20	30.81	1735.0	123.30	1030	7X2.57	36.30	45X3.85	523.90	82.9	17.1
CURLEW	590.20	31.59	1976.0	161.40	1025	7X3.51	67.70	54X3.51	522.50	72.6	27.4
BLUELJAY	604.40	31.98	1871.0	132.70	1060	7X2.66	38.90	45X4.00	565.50	83.0	17.0
FINCH	636.60	32.85	2133,0	174.60	1080	19X2.19	71.60	54X3.65	565.00	72.7	27.3
BUNTING	647.60	33.12	2005.0	142.30	1110	7X2.76	41.80	45X4.14	605.80	83.0	17.0
GRACKLE	679.70	33.97	2280.0	186.90	1125	19X2.27	76.90	54X3.77	602.80	72.6	27.4
BITTERN	689.10	34.17	2134.0	151.70	1155	7X2.85	44.70	45X4.27	644.40	82.9	17.1
PHEASANT	726.80	35.10	2435.0	194.10	1175	19X2.34	81.70	54X3.90	645.10	72.6	27.4
DIPPER	731.40	35.19	2265.0	160.70	1205	7X2.93	47.20	45X4.40	684.20	83.0	17.0
MARTIN	772.10	36.17	2587.0	206.10	1225	19X2.4"	86.70	54X4.02	685.40	72.8	27.2
BOBOLINK	775.40	36.24	2400.0	170.50	1250	7X3.02	50.10	45X4.53	725.30	83.0	17.0
NUTHATCH	817.00	37.20	2529.0	177.60	1295	7X3.10	52.80	45X4.65	764.20	83.0	17.0
PLOVER	818.70	37.24	2743.0	218.40	1270	19X2.48	91.80	54X4.14	726.90	72.8	27.2
PARROT	863.10	38.25	2892.0	230.50	1315	19X2.55	97.00	54X4.25	766.10	72.8	27.2
LAPWING	863.10	38.22	2671.1	187.40	1335	7X3.1F	55.60	45X4.78	807.80	83.0	17.0
FALCON	908.70	39.26	3047.0	243.10	1360	19X2.62	102.50	51X4.36	806.20	72.7	27.3
CHUKAR	976.70	40.70	3089.0	227.70	1435	19X2.2?	73.50	84X3.70	903.20	80.3	19.7
	1076.00	42.71	3222.0	208.40	1540	7X2.85	45.00	72X4.27	1031.00	87.9	12.1
KIWI	1147.00	44.10	3430.0	221.10	1600	7X2.9	47.00	72X4.41	1100.00	33.1	11.9
BLUEBIRD	1182.00	44.76	3740.0	268.30	1615	19X2.44	89.00	84X4.07	1093.00	80.3	19.7
THRASHER	1235.00	45.79	3761.0	251.80	1670	19X2.07	64.00	76X4.43	1171.00	85.6	14.4
JOREE	134.00	47.76	4095.0	274.50	1755	19X2.16	70.00	76X4.62	1274.00	85.4	14.0

ALUMINIUM CLAD STEEL STRANDED CONDUCTORS
DIN 48201/8

Cross Section	Construction							
Nominal	Actual	No. of Wires	Wire Diameter	Complete Conductor diameter	Conductor weight appr.	Calculated Breaking load	Calculated conductor resistance at 20°C	Current carrying capacity
mm^2	mm^2		mm	mm	Kg/km	kN	Ω/km	A
25	24.25		2.10	6.3	162	31.56	3.546	65
35	34.36	7	2.50	7.5	229	44.72	2.499	80
50	49.48	7	3.00	9.0	330	64.40	1.736	115
70	65.81	19	2.10	105	441	85.65	1.313	135
95	93.27	19	2.50	12.5	626	121.39	0.925	170
120	116.99	37	2.80	14.0	785	152.26	0.737	195
150	147.11	37	2.25	15.7	990	191.46	0.587	225
185	181.62	37	2.50	17.5	1221	236.38	0.476	255
240	242.54	61	2.25	20.2	1635	299.05	0.357	310
300	299.43	61	2.50	22.5	2017	369.20	0.289	355

ALL ALUMINIUM ALLOY CONDUCTORS STEEL REINFORCED (AACSR) NFC 34-125

Cross Word	Total Cross Section	Complete conductor diameter	Conductor weight approx.	Calc. Breaking Load.	Elec. Resistance at 20°C	Construction Steel	Section Steel	Construction AAA	Section AAA	AlMGsi	Steel
	mm^2	mm	Kg/km	kN	Ω/km	mm	mm^2	mm	mm	%	%
PHLOX	37.7	8.30	155	23.60	1.170	3X2.00	9.42	9X2.00	28.27	50	50
PHLOX	59.7	10.00	276	45.60	0.880	7X2.00	21.99	12X2.00	37.70	37.6	62.4
PHLOX	75.5	11.25	348	57.70	0.695	7X2.25	27.83	12X2.25	47.71	37.6	62.4
PHLOX	94.1	12.80	481	80.35	0.642	19X1.68	42.12	15X2.10	51.95	29.7	70.3
PHLOX	116.2	14.00	636	108.15	0.580	19X2.00	59.69	18X2.00	56.55	24.4	75.6
PHLOX	147.1	15.75	802	136.85	0.466	19X2.25	75.54	18X2.25	71.57	24.5	75.5
PASTEL	147.1	15.75	547	81.85	0.279	7X2.25	27.83	30X2.25	119.28	59.9	40.1
PHLOX	181.6	17.50	990	168.95	0.378	19X2.50	93.27	18X2.50	88.36	24.5	75.5
PASTEL	181.6	17.50	675	101.20	0.227	7X2.50	34.36	30X2.50	147.26	59.9	40.1
PHLOX	228.0	19.60	1244	212.00	0.300	19X2.80	116.99	18X2.80	110.83	24.5	75.5
PASTEL	228.0	19.60	848	126.80	0.180	7X2.80	43.10	30X2.80	184.72	59.8	40.2
PHLOX	288.0	22.50	1570	268.00	0.237	19X3.15	148.07	18X3.15	140.28	24.5	75.5
PASTEL	288.0	22.05	1074	160.50	0.142	7X3.15	54.55	30X3.15	233.80	59.8	40.2
PASTEL	299.0	22.05	1320	208.75	0.162	19x2.50	93.27	42x2.50	206.17	42.9	57.1
PHLOX	376.0	25.20	2211	389.60	0.225	37X2.80	227.83	24X2.80	147.78	18.4	81.6
PASTEL	412.0	26.40	1593	238.30	0.103	19X2.40	85.95	32X3.60	325.72	56.1	43.9
PETUNIA	612.0	32.20	2241	326.90	0.065	19X2.65	104.79	104.79 42X2.61	507.10	62.1	37.9
PETUNIA	865.0	38.10	3174	460.00	0.047	19X3.15	148.06	66X3.72	717.33	62.1	37.9
POLYGO NUM	1185.0	44.70	4475	663.85	0.035	37X2.80	227.82	54X2.80 66X3.47	956.66	58.7	41.3

ALL ALUMINIUM ALLOY CONDUCTORS STEEL REINFORCED (AACSR) DIN 48206

Nominal Cross section	Total Cross Section	Complete conductor diameter	Conductor weight approx.	Calc. Breaking Load.	Elec. Resistance at 20°C	Construction Steel	Section Steel AAL	Construction AAA	Section	AAAC	Steel
	mm^2	mm	Kg/km	kN	Ω/km	mm	mm^2	mm	mm	%	%
16/2.5	17.85	5.40	62	7.70	2.181	1X1.80	2.55	6X1.80	15.30	67.8	32.2
25/4	27.80	6.75	96	12.00	1.396	1X2.25	4.00	6X2.25	23.80	68.1	31.9
35/6	40.00	8.10	140	17.15	0.969	1X2.70	5.70	6X2.70	34.30	67.3	32.7
44/32	75.70	11.20	374	51.50	0.763	7X2.40	31.70	14X2.00	44.00	32.3	67.7
50/8	56.30	9.60	196	24.15	0.690	1X3.20	8.00	6X3.20	48.30	67.8	32.2
50/30	81.00	11.70	378	51.20	0.655	7X2.33	29.80	12X2.83	51.20	37.2	62.8
70/12	81.30	11.70	283	34.70	0.479	7X1.44	11.40	26X2.85	69.90	67.8	32.2
94/22	116.20	14.00	432	54.80	0.356	7X2.00	22.00	30X2.00	94.20	59.9	40.1
95/15	109.70	13.60	382	46.80	0.355	7X1.67	15.30	26X2.15	94.40	67.9	32.2
95/34	131.10	14.90	537	70.55	0.347	7X2.50	34.40	36X85	96.80	49.5	50.5
95/55	152.80	16.00	713	96.85	0.347	7X3.20	56.30	12X3.20	96.50	37.2	62.8
105/75	181.50	17.50	894	122.80	0.318	19X2.25	75.50	14X3.10	105.70	32.5	67.5
120/20	141.40	15.50	493	60.35	0.276	7X1.90	19.80	26X2.44	121.60	67.7	32.3
120/42	160.40	16.50	654	85.80	0.276	7X2.75	41.60	36X2.05	118.80	49.9	50.1
120/70	193.30	18.00	903	122.60	0.274	7X3.60	71.30	12X3.60	122.00	37.1	62.9
125/30	157.70	16.30	590	74.20	0.262	7X2.33	29.80	30X2.33	127.90	59.5	40.5
150/25	173.10	17.10	604	73.85	0.225	7X2.10	24.20	26X2.70	148.90	67.7	32.2
150/53	202.40	18.50	827	108.55	0.224	7X3.10	52.80	36X2.30	149.60	49.7	50.3
170/40	211.90	18.90	792	99.90	0.195	7X2.70	40.10	30X2.70	171.80	59.6	40.4
185/30	213.60	19.00	744	91.00	0.182	7X2.33	29.80	26X3.00	183.80	67.8	32.2
210/35	243.20	20.30	848	103.90	0.160	7X2.68	39.50	26X3.45	243.00	67.9	32.1
210/50	261.60	21.00	978	123.35	0.158	7X3.00	49.50	30X3.00	212.10	59.6	40.4
230/30	260.70	21.00	873	105.10	0.145	7X2.33	29.80	24X3.50	230.90	72.6	27.4
240/40	282.50	21.90	983	120.50	0.138	7X2.49	34.10	26X3.20	243.00	67.7	32.3
257/60	316.50	23.10	1177	149.20	0.131	7X3.30	59.90	30X3.30	256.60	59.9	40.1
265/35	297.80	22.40	998	120.20	0.127	7X2.49	34.10	24X3.74	263.70	72.6	27.4
300/50	353.70	24.50	1232	151.00	0.110	7X3.00	49.50	26X3.86	304.20	67.8	32.2
305/40	344.10	24.10	1155	136.12	0.108	7X2.68	39.49	54X2.68	304.62	72.4	27.6
340/30	369.10	25.00	1174	134.94	0.099	7X2.33	29.85	48X3.00	339.29	79.4	20.6
340/110	450.00	27.70	1799	233.55	0.098	19X2.70	108.80	78X2.36	341.20	52.1	47.9
380/50	431.20	27.00	1448	170.56	0.087	7X3.00	49.48	54X3.00	381.70	72.4	27.6
385/35	420.10	26.70	1336	153.69	0.085	7X2.49	34.09	48X3.20	386.04	79.4	20.6
435/55	490.60	28.80	1647	194.06	0.076	7X3.20	56.30	54X3.20	434.29	72.4	27.6
450/40	488.20	28.70	1553	178.48	0.074	7X2.68	39.49	48X3.45	448.71	79.3	20.7
490/65	553.80	30.60	1860	219.07	0.068	7X3.40	63.55	54X3.40	490.28	72.4	27.6
550/70	620.90	32.40	2085	245.60	0.060	7X3.60	71.25	54X3.60	549.65	72.4	27.6
560/50	611.20	32.20	1943	223.48	0.059	7X3.00	49.48	48X3.86	561.70	79.4	20.6
680/85	764.50	36.00	2564	300.84	0.048	19X2.40	35.95	54X4.00	678.58	72.7	27.3

ALUMINIUM WIRES AND ALUMINIUM STRANDED CONDUCTORS DIN 48203 Part - 5

Table 1. Fixed values

Number of wires	linear force due to mass per unit cross sectional (OLK) N/m mm²	Coefficient of linear expansion 1/K	Practical modulus of elasticity
7	0.0275	23-10.	60
19			57
37			57
61			55
91			55

Table 2. Stranding constants

Number of wires	Stranding constants for	
	Mass	Electrical Resistance
7	7.091	1447
19	19.34	0.05357
37	37.74	0.02757
61	62.35	0.01676
91	93.26	0.01126

Material	Wires	Stranded Conductors	Technical delivery conditions		IEC
			New	Previous	
Copper	DIN 48 200 Part 1	DIN 408 201 Part 1	DIN 48 203 Part 1	DIN 48 202 Part 2	-
Wrought Copper Alloys (Bz)	DIN 48 200 Part 2	DIN 408 201 Part 2	DIN 48 203 Part 2	DIN 48 202 Part 2	-
Steel	DIN 48 200 Part 3	DIN 408 201 Part 3	DIN 48 203 Part 3	DIN 48 202 Part 1	-
Aluminium	DIN 48 200 Part 5	DIN 408 201 Part 5	DIN 48 203 Part 5	DIN 48 202 Part 1	207
E-AlMgsi	DIN 48 200 Part 6	DIN 408 201 Part 6	DIN 48 203 Part 6	DIN 48 202 Part 3	208
Copper covered steel	DIN 48 200 Part 7	DIN 408 201 Part 7	DIN 48 203 Part 7	DIN 48 202 Part 5	-
Aluminium-clad steel	DIN 48 200 Part 8	DIN 408 201 Part 8	DIN 48 203 Part 8	DIN 48 202 Part 1 *)	-
Steel reinforced Aluminium		DIN 48 204	DIN 48 203 Part 11	DIN 48 202 Part 1	209
Steel reinforced E-AlMgsi		DIN 48 206	DIN 48 203 Part 12	DIN 48 202 Part 4	210
▪ 1 January 1975 draft					

WIRES FOR STRANDED CONDUCTORS

ALUMINIUM WIRES
DIN 48 200 PART - 5

Nominal diameter[1] (mm)		Wire cross section (mm²)	Tensile strength (N/mm²)		Resistance per unit length.	Mass (2.7 kg/dm.) in kg
	Permissible deviation		Before Standing (min)	After Stranding (min)	(W/km) min	(Kg/km)
1.50	± 0.03	1.77	193	183	15.99	4.8
1.75		2.41	188	179	11.75	6.5
2.00		3.14	184	176	9.00	8.5
2.25		3.98	181	172	7.11	10.7
2.50		4.91	177	168	5.76	13.3
2.75		5.94	173	164	4.76	16.0
3.00		7.07	169	160	4.00	19.1
3.25	± 0.04	8.30	166	157	3.41	22.4
3.50		9.62	164	156	2.94	26.0
3.75		11.04	162	154	2.56	29.8
4.00		12.57	160	152	2.25	33.9
4.25		14.19	160	152	1.99	38.3
4.50		15.90	159	151	1.78	42.9

1. Intermediate values are permitted. In this case, the permissible deviations for the next largest diameter given in the table shall apply.
2. For wire with intermediate diameters, the values given in the table for the next largest diameter shall apply.
3. The resistance per unit length is calculated for the nominal wire cross section, taking the specified minimum conductivity as the basis. The values shall be converted accordingly for plus or minus deviations from the wire dimeter

WIRES FOR STRANDED CONDUCTORS

Steel Wires
DIN 48 200 Part 3

Table - 2

Gauge length	At an initial stress, in N/mm²		
in mm	**100**	**200**	**300**
50	0.025 mm	0.05 mm	0.075 mm
200	0.100 mm	0.20 mm	0.300 mm
250	0.125 mm	0.25 mm	0.375 mm

A density of 7.8 kg/dm3 shall be used as the basis for calculating the mass.
Zinc coating

Table - 3

Nominal diameter, in mm	Mass per unit area g/m²	Number of inersions²
1.35 to 1.55	190	2
1.56 to 1.75	200	2
1.76 to 2.24	210	
2.25 to 2.74	230	3
2.75 to 3.05	240	3
3.06 to 3.49	250	3'
3.50 to 4	260	3
over 4	275	4

1. The values shall apply for the final (galvanized) condition.
2. Testing shall be carried out as specified in DIN 48202 Part 3. Finish drawn and galvanized.

Table - 1

Nominal Diameter (mm)		Steel I	Steel II		Steel III			Steel VI		
		Tensile Strength	Tensile Strength		Tensile Stress at 1% Extension[1] N/mm² (min)	Tensile Strength		Tensile Stress at 1% Extension[1] N/mm² (min)	Tensile Strength	
	Permissible deviation	N/mm² ≈	Before Stranding N/mm² (min)	After Stranding N/mm² (min)		Before Stranding N/mm² (min)	After Stranding N/mm² (min)		Before Stranding N/mm²	After Stranding N/mm² (min)
1.35 to 1.75	±0.035	390	690	650	1180		1250	1310		1540
1.76 to 2.74	±0.04					1310 to		1270	1570 to	
2.75 to 3.49	±0.05	390	690	650	1140	1250		1250	1810	1490
3.5 to 4.95	± 0.06				1100		1250	1180		

1) The intial stress prior to the application of the extensometer shall be
For nominal diameters up to 2.25 mm: 100 N/mm² :for nominal diameters over 2.25 upto 3mm: 200 N/mm² For nominal diameters over 3mm: 300 N/mm².
The extensometer reading at this initial stress is the starting point for the measurement of the 1% extension and shall have the value given in the following table.

STEEL REINFORCED ALUMINIUM STRANDED CONDUCTORS
DIN 48 204
Conductor DIN 48 204-95/15-AL/St

Table 1.
Dimensions, Mechanical and Electrical values

1	2	3	4	5	6	7	8
Nominal cross section	Required cross section	Cross section ratio Alu./St.	Conductor diameter	Mass[1] Kg/km	Theoretical breaking force[2]	Resistance per unit length	Current carrying capacity[3]
mm2	mm2	-	mm	-	kN	Ω/km	A
16/2.5	17.8	6	5.4	62	5.81	1.8793	105
25/4	27.8	6	6.8	97	9.02	1.2028	140
35/6	40.1	6	8.1	140	12.7	0.8353	170
44/32	75.7	1.4	11.2	373	45.46	0.6573	-
50/8	56.3	6	9.6	196	17.18	0.5946	210
50/30	81.0	1.7	11.7	378	44.28	0.5644	-
70/12	81.3	6	11.7	284	26.31	0.4130	290
95/15	109.7	6	13.6	383	35.17	0.3058	350
95/55	152.8	1.7	16.0	714	80.20	0.2992	-
105/75	181.2	1.4	17.5	899	106.69	0.2736	-
120/20	141.4	6	15.5	494	44.94	0.2374	410
120/70	193.4	1.7	18.0	904	98.16	0.2364	-
125/30	157.8	4.3	16.3	590	57.86	0.2259	425
150/25	173.1	6	17.1	604	54.37	0.1939	470
170/40	211.9	4.3	18.9	794	77.01	0.1682	520
185/30	213.6	6	19.0	744	66.28	0.1571	535
210/35	243.2	6	20.3	848	74.94	0.1380	590
210/50	261.5	4.3	21.0	979	92.25	0.1363	610
230/30	260.8	7.7	21.0	874	73.09	0.1249	630
240/40	282.5	6	21.8	985	86.46	0.1188	645
265/35	297.8	7.7	22.4	998	82.94	0.1094	680
300/50	353.7	6	24.5	1233	105.09	0.0949	740
305/40	344.1	7.7	24.1	1155	99.30	0.0949	740
340/30	369.1	11.3	25.0	1174	92.56	0.0851	790
380/50	431.2	7.7	27.0	1448	120.91	0.0757	840
385/35	420.1	11.3	26.7	1336	104.31	0.0748	850
435/55	490.6	7.7	28.8	1647	136.27	0.0666	900
450/40	488.2	11.3	28.7	1553	120.19	0.0644	920
490/65	553.8	7.7	30.6	1860	152.85	0.0590	960
495/35	528.4	14.5	29.9	1636	120.31	0.0584	985
510/45	555.8	11.3	30.7	1770	134.33	0.0566	995
550/70	620.9	7.7	32.4	2085	167.42	0.0526	1020
560/50	611.2	11.3	32.2	1943	146.28	0.0514	1040
570/40	610.7	14.5	32.2	1889	137.98	0.0506	1050
650/45	698.8	14.5	34.4	2163	155.52	0.0442	1120
680/85	764.5	7.7	36.0	2564	209.99	0.0426	1150
1045/45	1090.9	23.1	43.0	3249	217.87	0.0277	1580

STEEL REINFORCED ALUMINIUM STRANDED CONDUCTORS DIN 48 204

Table 2 : Construction of Conductor

1	2	3	4	5	6	7	8	9
	Aluminium parts				Steel parts			
Nominal cross section	WIRE		OUT SIDE LAYER		WIRES		Core	
mm^2	Number	Diameter (mm)	Number of wire layers	Cross section (mm^2)	Number	Diameter (mm)	Diameters (mm)	Cross section (mm^2)
16/2.5	6	1.80	1	15.27	1	1.80		2.54
25/4	6	2.25	1	23.86	1	2.25		3.98
35/6	6	2.70	1	34.35	1	2.70	-	5.73
44/32	14	2.00	1	43.98	7	2.40	7.20	31.67
50/8	6	3.20	1	48.25	1	3.20		8.04
50/30	12	2.33	1	51.17	7	2.33	6.99	29.85
70/12	26	1.85	2	69.89	7	1.44	4.32	11.40
95/15	26	2.15	2	94.39	7	1.67	5.01	15.33
95/55	12	3.20	1	96.51	7	3.20	9.60	56.30
105/75	14	3.10	1	105.67	19	2.25	11.25	75.55
120/20	26	2.44	2	121.57	7	1.90	5.70	19.85
120/70	12	3.60	1	122.15	7	3.60	10.80	71.25
125/30	30	2.33	2	127.92	7	2.33	6.99	29.85
150/25	26	2.70	2	148.86	7	2.10	6.31	24.25
170/40	30	2.70	2	171.77	7	2.70	8.10	40.08
185/30	26	3.00	2	183.78	7	2.33	6.99	29.85
210/35	26	3.20	2	209.10	7	2.49	7.74	34.09
210/50	30	3.00	2	212.06	7	3.00	9.00	49.48
230/30	24	3.50	2	230.91	7	2.33	6.99	29.85
240/40	26	3.45	2	243.05	7	2.68	8.04	39.49
265/35	24	3.74	2	263.66	7	2.49	7.47	34.09
300/50	26	3.86	2	304.26	7	3.00	9.00	49.48
305/40	54	2.68	3	304.62	7	2.68	8.04	39.49
340/30	48	3.00	3	339.29	7	2.33	6.99	29.85
380/50	54	3.00	3	381.70	7	3.00	9.00	49.48
385/35	48	3.20	3	386.04	7	2.49	7.47	34.09
435/55	54	3.20	3	434.29	7	3.20	9.60	56.30
450/40	48	3.45	3	448.71	7	2.68	8.04	39.49
490/65	54	3.40	3	490.28	7	3.40	10.20	63.55
495/35	45	3.74	3	494.36	7	2.49	7.47	34.09
510/45	48	3.68	3	510.54	7	2.87	8.61	45.28
550/70	54	3.60	3	549.65	7	3.60	10.80	71.25
560/50	48	3.86	3	561.70	7	3.00	9.00	49.48
570/40	45	4.02	3	571.16	7	2.68	8.04	39.49
650/45	45	4.30	3	653.49	7	2.87	8.61	45.28
680/85	54	4.00	3	678.58	19	2.40	12.00	85.95
1045/45	72	4.30	4	1045.58	7	2.87	8.61	45.28

Table 3 Lay Ratio for Steel wires

1	2	3	4	5
	Lay Ratio			
Number of wires in conductor	1st layer		2nd layer	
	min	mix	min	mix
7	13	28		
19	13	28	12	24

Table 4 Lay ratio for Aluminium wires

1	2	3	4	5	6	7	8	9
	Lay Ratio							
Number of wires in conductor	1st layer		2nd layer		3rd layer		4th layer	
	min	mix	min	mix	min	mix	min	mix
6 12 14	10	14						
24 26 30	10	16	10	14	-	-		
45 48 54	10	17	10	16	10	14	-	-
72	10	17	10	16	10	15	10	14

Table 5
Aluminium parts
Proportion of Aluminium

Ratio of cross-sectional area of Aluminium to Steel (Alu./St.).	Proportion by mass of Aluminium to total mass %
1.4	32.5
1.7	37.3
4.3	59.8
6 (single-layer)	67.3
6 (multi-layer)	68.0
7.7	72.8
11.3	79.7
14.5	83.4
23.1	88.9

STEEL WIRES AND STEEL STRANDED CONDUCTORS
DIN 48 203 Part 3

Table 1. Fixed values for steels Ito VI

Number of wires	Linear force due to mass per unit cross section (QM N/m.me	Coefficient of linear expansion 1/K	Practical modulus of elasticity kN/mm^2
7	0.0792	11.10^{-6}	180
19			175

Table 2. Stranding Constants

Number of wires	Stranding constants for mass
7	7.091
19	19.34

Material	Wires	Stranded Conductors	Technical delivery conditions		IEC
			New	Previous	
Copper	DIN 48 200 Part 1	DIN 408 201 Part 1	DIN 48 203 Part 1	DIN 48 202 Part 2	-
Wrought Copper Alloys (Bz)	DIN 48 200 Part 2	DIN 408 201 Part 2	DIN 48 203 Part 2	DIN 48 202 Part 2	-
Steel	DIN 48 200 Part 3	DIN 408 201 Part 3	DIN 48 203 Part 3	DIN 48 202 Part 1	-
Aluminium	DIN 48 200 Part 5	DIN 408 201 Part 5	DIN 48 203 Part 5	DIN 48 202 Part 1	207
E-AIMgsi	DIN 48 200 Part 6	DIN 408 201 Part 6	DIN 48 203 Part 6	DIN 48 202 Part 3	208
Copper covered steel	DIN 48 200 Part 7	DIN 408 201 Part 7	DIN 48 203 Part 7	DIN 48 202 Part 5	-
Aluminium-clad steel	DIN 48 200 Part 8	DIN 408 201 Part 8	DIN 48 203 Part 8	DIN 48 202 Part 1 *)	-
Steel reinforced Aluminium		DIN 48 204	DIN 48 203 Part 11	DIN 48 202 Part 1	209
Steel reinforced E-AIMgsi		DIN 48 206	DIN 48 203 Part 12	DIN 48 202 Part 4	210
▪ 1 January 1975 draft					

Steel-reinforced Aluminium Stranded Conductors
Technical delivery conditions
Table 1. Properties of stranded conductor

Approximate ratio of Aluminium /Steel cross-sectional areas	Number of wires Alu./St.	Mass per unit length and cross-sectional area.	Coefficient of linear thermal expansion	Modulus of Elasticity
	Alu/St.	N/m-mm²	1/K	kN/mm²
1.4	14/7 14/19	0.0491	15.10^{-6}	110
1.7	12/7	0.0466	$15{,}3.10^{-6}$	107
4.3	30/7	0.0375	$17{,}8.10^{-6}$	82
6	6/1 26/7	0.035	$19{,}2.10^{-6}$ $18{,}9.10^{-6}$	81 77
7.7	24/7 54/7 54/19	0.0336	$19{,}6.10^{-6}$ $19{,}3.10^{-6}$ $19{,}4.10^{-6}$	74 70 6
11.3	48/7	0.032	$20{,}5.10^{-6}$	62
14.5	45/7	0.0309	$20{,}9.10^{-6}$	61
23.1	72/7	0.0298	$21{,}7.10^{-6}$	60

The mass per unit and cross-sectional area is the load per m conductor length and per mm² conductor cross section, on which the calculation of the conductor sag is to be based.

DIN 48 203 PART 11
Table 2. Stranding constants

Number of wires		Stranding constants for calculating		
Aluminium	Steel	Aluminium	Steel	Electrical Resistance
6	1	6.091	1	0.1692
12	7	12.26	7.032	0.08514
14	7	14.32	7.032	0.07306
14	19	14.32	19.15	0.07306
24	7	24.5	7.032	0.04253
26	7	26.56	7.032	0.03928
30	7	30.67	7.032	0.03408
45	7	45.98	7.032	0.02271
48	7	49.06	7.032	0.02129
54	7	55.23	7.032	0.01894
54	19	55.23	19.15	0.01894
72	7	73.68	7.032	0.01421

Material	Wires	Stranded Conductors	Technical delivery conditions		IEC
			New	Previous	
Copper	DIN 48 200 Part 1	DIN 408 201 Part 1	DIN 48 203 Part 1	DIN 48 202 Part 2	-
Wrought Copper Alloys (Bz)	DIN 48 200 Part 2	DIN 408 201 Part 2	DIN 48 203 Part 2	DIN 48 202 Part 2	-
Steel	DIN 48 200 Part 3	DIN 408 201 Part 3	DIN 48 203 Part 3	DIN 48 202 Part 1	-
Aluminium	DIN 48 200 Part 5	DIN 408 201 Part 5	DIN 48 203 Part 5	DIN 48 202 Part 1	207
E-AlMgsi	DIN 48 200 Part 6	DIN 408 201 Part 6	DIN 48 203 Part 6	DIN 48 202 Part 3	208
Copper covered steel	DIN 48 200 Part 7	DIN 408 201 Part 7	DIN 48 203 Part 7	DIN 48 202 Part 5	-
Aluminium-clad steel	DIN 48 200 Part 8	DIN 408 201 Part 8	DIN 48 203 Part 8	DIN 48 202 Part 1 *)	-
Steel reinforced Aluminium		DIN 48 204	DIN 48 203 Part 11	DIN 48 202 Part 1	209
Steel reinforced E-AlMgsi		DIN 48 206	DIN 48 203 Part 12	DIN 48 202 Part 4	210
▪ 1 January 1975 draft					

DICABS
POWERING PROGRESS

USA - ASTM STANDARD B 399

Aluminium Alloy 6201 T-81 Condcutors
(Same diameter as ACSR Conductors)

Code Name	Conductor	Number of wires	Wire dia.	Cable dia.	ACSR Conductor of same dia. AWG or KCmil and Stranding	Weight per 1000 ft	Breaking load	Resistance at 20°C
	KCmil		(in)	(in)		lbs	lbs	Odmiles
Akron	35.58	7	0.0661	0.198	0.02402	6.6/1	28.2	3.479
Alton	48.69	7	0.0834	0.250	0.03824	4-6/1	45.7	2.185
Ames	77.47	7	0.1052	0.316	0.06084	2-6/1	72.7	1.373
Azusa	123.3	7	0.1327	0.398	0.09681	1/0-6/1	115.7	0.8631
Anaheim	155.4	7	0.149	0.447	0.1221	2/0-6/1	145.9	0.6846
Amherst	195.7	7	0.1672	0.502	0.1537	3/0-6/1	183.7	0.5437
Alliance	246.9	7	0.1878	0.563	0.1939	4/0-6/1	231.8	0.4309
Butte	312.8	19	0.1283	0.642	0.2456	266-26/7	293.6	0.3402
Canton	394.5	19	0.1441	0.721	0.3098	336-26/7	370.3	0.2697
Cairo	465.4	19	0.1565	0.783	0.3655	397-26/7	436.9	0.2286
Darien	559.5	19	0.1716	0.858	0.4394	477-26/7	525.2	0.1902
Elgin	652.4	19	0.1853	0.927	0.5124	556-26/7	612.4	0.1631
Elint	740.8	37	0.1415	0.991	0.5818	636-26/7	695.4	0.1436
Greeley	927.2	37	0.1583	1.108	0.7282	795.26/7	870.4	0.1148

USA - ASTM STANDARD B 399 M (metric)
Aluminium Alloy 6201 T-81 Conductors

Conductor section	Number of wires	Wire dia.	Breaking load
mm^2		mm	kN
630	37	4.66	181
560	37	4.39	161
500	37	4.15	143
450	37	3.94	129
400	37	3.71	115
355	37	3.5	102
315	37	3.29	90.2
280	19	3.1	83.9
250	19	4.09	73.1
224	19	3.87	65.5
200	19	3.66	58.6
180	19	3.47	52.6
160	19	3.27	46.7
140	19	3.06	42.9
125	19	2.89	38.3
112	7	4.51	33.8
100	7	4.26	30.2
80	7	3.81	24.1
63	7	3.39	19.1
50	7	3.02	15.9
40	7	2.7	12.7
31.5	7	2.39	9.95
25	7	2.13	7.9
20	7	1.91	6.35
16	7	1.71	5.09

BS : 3242

2. MATERIAL

The conductor shall be constructed of heat treated Aluminium - Magnesium Silicon Alloy wires having the mechanical and electrical properties specified in this British Standard.

NOTE. A suitable material is one containing amounts of Magnesium and Silicon appropriates to the mechanical and electrical properties specified and containing not more than 0.05% coppers.

By agreement between the purchaser and the manufacturer suitable grease may be applied to the center wire, or additionally to wires in specific layers, evenly throughout the length of the conductor.

3. DIMENSIONS AND CONSTRUCTION

3.1 STANDARD SIZES OF WIRES

After drawing and heat treatment, the Aluminium Alloy wires for the standard constructions covered by this specifications shall have the diameters specified in Table 2.

3.2 TOLERANCES ON THE STANDARD DIAMETERS OF WIRES

A tolerance of ± 1% is permitted on the standard diameters of all wires. The cross section of any wire shall not depart from circularity by more than an amount corresponding to a tolerance of 1% on the standard diameter.

3.3 STANDARD SIZES OF ALUMINIUM ALLOY STRANDED CONDUCTORS

The sizes of standard Aluminium Alloy stranded conductors are given in Table 3. The masses (excluding the mass of grease for corrosion protection and resistances may betaken as being in accordance with Table 3.

3.4 JOINTS IN WIRES

3.4.1 Conductors containing more than seven wires: There shall be no joints in any wire of a stranded conductor containing seven wires, except those made in the base rod or wire before final drawing.

3.4.2 Conductors containing more than seven wires: in stranded conductors containing more than seven wires, in addition to joints made in the base rod before final drawing, joints in individual wires made by cold-pressure bull-welding are permitted in any layer and those made by resistance bull-welding are permitted in any layer except the outermost layer. No two such joints shall be less than 15m apart in the complete stranded conductors. They are not required to fulfill the mechanical or electrical requirements for unjointed wire. Joints made by resistance bull-welding shall, subsequent to welding, be annealed over a distance of a least 200mm on each side of the joint.

3.5 STRANDING

3.5.1 The wire used in the construction of a stranded conductor shall, before stranding, satisfy all the relevant requirements of this standard.

3.5.2 The lay ratio of the different layers shall be within the limits given in Table. 1

NOTE: It is important to note that lay ratio is now defined as the ratio of the axial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the external diameter of the helix.

3.5.3 In all constructions, the successive layers shall have opposite directions of lay, the outermost layer being right handed. The wires in each layer shall be evenly and closely stranded.

3.5.4 In Aluminium Alloy stranded Conductors having multiple layers of wires, the lay ratio of any layer shall be not greater than the lay ratio of the layer immediately beneath it.

TABLE 1: LAY RATIOS FOR ALUMINIUM ALLOY STRANDED CONDUCTORS

Number of wires in conductor	Lay ratio					
	6-wire layer		12-wire layer		18-wire layer	
	min	max	min	max	min	max
7	10	14	--	--	--	--
19	10	16	10	14	--	--
37	10	17	10	16	16	14

4. TESTS

4.1 SELECTION OF TEST SAMPLES

4.1.1 Samples for the tests specified in 4.3 and 4.4 shall betaken by the manufacturer before stranding, from not less than 10% of the individual lengths of Aluminium Alloy wire included in any one final heat treatment batch. One sample, sufficient to provide one test specimen for each test, shall betaken from each of the selected lengths of wire.

4.1.2 Alternatively, when the purchaser states at the time of ordering that he desire tests to be made in the presence of his representative, samples of wire shall be taken from lengths of stranded conductor selected from approximately 10% of the lengths included in any one consignment. One sample, sufficient to provide one specimen for each of the appropriate tests, shall betaken from each of an agreed number of wires of the conductor in each of the selected lengths.

4.2 PLACE OF TESTING

Unless otherwise agreed between the purchaser and the manufacturer at the time of ordering, all tests shall be made at the manufacturer's works.

4.3 MECHANICAL TESTS

4.3.1 Tensile test. The test shall be made in accordance with BS 18*, on a specimen cut from each of the samples taken as specified on 4.1.1 or 4.1.2. The load shall be applied gradually and the rate of separation of the jaws of the testing machine shall be not less than 25 mm/min and not greater than 100mm/min.

When tested before or after stranding, the tensile strength of the specimen shall be not less than 29.5 hbart.

4.3.2 Elongation test. The test shall be made in accordance with BS 18*. The load shall be applied gradually and uniformly on a specimen cut from each of the samples taken as specified in 4.1.1 or 4.1.2 having an original gauge length of 250mm.

The elongation shall be measures on the gauge length after the fractured ends have been fitted together The determination shall be valid, whatever the position of the fracture, if the specified values in reached. If the specified value is not reached, the determination shall be valid only if the fracture occurs between the gauge marks and not closer than 25mm to either mark.

When tested before of after stranding, the elongation shall be not less than 3.5%.

4.4 ELECTRICAL RESISTIVITY TEST

The resistivity of one specimen cut from each of the samples taken as specified in 4.1.1 or 4.1.2 shall be determined in accordance with the routine method give in Bs3239+.

The resistivity at 20° C shall not exceed 3.28 mw/cm.

4.5 CERTIFICATE OF COMPLIANCE

When the purchaser does not call for tests on wires taken from the stranded conductor the manufacturer shall, if requested, furnish him with a certificate giving the results of the tests made on the samples taken in accordance with 4.1.1.

TABLE 2: ALUMINIUM ALLOY WIRES USED IN THE CONSTRUCTION OF STANDARD ALUMINIUM ALLOY STRANDED CONDUCTORS

Standard diameter	Cross sectional area of standard diameter Wire	Mass per	Standard resistance at 20° C per km	Minimum breaking load for standard diameter wire	Standard diameter
mm	mm^2	Km/kg	x	N	mm
2.34	4.301	11.61	7.557	1270	2.34
2.54	5.067	13.68	6.414	1490	2.54
2.95	6.835	18.45	4.755	2020	2.95
3.30	8.553	23.09	3.800	2520	3.30
3.48	9.511	25.68	3.417	2810	3.48
3.53	9.787	26.42	3.321	2890	3.53
3.76	11.10	29.98	2.927	3280	3.76
4.65	16.98	45.85	1.914	5010	4.65

Note: The values given in Columns 2 to 5 are given for information only.

TABLE 3: STANDARD ALUMINIUM ALLOY STRANDED CONDUCTORS

1	2	3	4	5	6	7	1
Nominal Aluminium area	Stranding and wire diameter	Sectional area	Approximately overall diameter	Approximately mass per km	Calculated D.C. resistance at 20° C Ω/ km	Calculated breaking load	Nominal Aluminium area
mm^2	mm	mm^2	mm	kg	Ω	kN	mm^2
25	7/2.34	30.10	7.02	82	1.094	8.44	25
30	7/2.54	35.47	7.62	97	0.928 1	9.94	30
40	7/2.95	47.384	8.85	131	0.683 0	13.40	40
50	7/3.30	59.87	9.90	164	0.549 8	16.80	50
100	7/4.65	118.9	13.95	325	0.276 9	33.30	100
150	19/3.48	180.7	17.40	497	0.183 0	50.64	150
175	19/3.76	211.0	18.80	580	0.156 8	59.10	175
300	37/3.53	362.1	24.71	997	0.09155	101.5	300

Note:

1. For the basic of calculation of this table, see Appendix A.
2. The sectional area of an Aluminium Alloy Stranded Conductor is the sum of the cross sectional area of the individual wires.
3. Attention is drawn tothe fact that the sectional areas of standard conductors covered by the specification refer to Aluminium Alloy areas. consequently they are larger than the nominal aluminium areas by which they are identified.

APPENDIX A
NOTES ON THE CALCULATION OF TABLE 3

A-1 Increase in length due to stranding. When straightened out, each wire in any particular layer of a stranded conductor, except the central wire, is longerthan the stranded conductor by an amount depending on the lay ratio of that layer.

A-2 Resistance and mass of conductor. The resistance of any length of a stranded conductor is the resistance of the same length of any one wire multiplied by a constant asset out in Table 4.

The mass of each wire in any particular layer of stranded conductor except the central wire, will be greater than that of an equal length of straight wire by an amount depending on the lay ratio of that layer (see A-1 above). The total mass of any length of an Aluminium Alloy Stranded Conductor is, therefore obtained by multiplying the mass of an equal length of straight wire by an appropriate constant, as set out in Table 4.

In calculating the stranding constants in Table 4, the mean lay ratio i.e. the arithmetic mean of the relevant minimum and maximum values in Table 1, has been assumed for each layer.

A-3 Calculated breaking load of conductor. The breaking load of an Aluminium Alloy Stranded Conductor in terms of the strengths of the individual component wires, may be taken to be 95% of the sum of the strengths of the individual Aluminium Alloy wires calculated from the value of the minimum tensile strength given in 4.3.1.

TABLE 4: STRANDING CONSTANTS

Numbers of wire in conductor	Stranding constants Mass	Electrical resistance
7	7.091	0.1447
19	19.34	0.05357
37	37.34	0.02757

ANNEX A (Foreword)

MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

No. of Wires	Final Modulus of Elasticity (GN/m²)	Coefficient of Linear Expansion (°C-¹)
3	0.6500×10^6 kg/cm²	23.0×10^{-6}
7	0.6324×10^6 kg/cm²	23.0×10^{-6}
19	0.612×10^6 kg/cm²	23.0×10^{-6}
37	0.5814×10^6 kg/cm²	23.0×10^{-6}
61	0.5508×10^6 kg/cm²	23.0×10^{-6}

NOTE: These values are given for information only.

APPENDIX B

NOTE ON MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

The practical module of elasticity given below are based on an analysis the final module determined from a large number short-term stress/strain tests and may be taken as applying to conductors stressed between 15% and 50% of the breaking load of the conductor. They may be regarded as being accurate to within ± 300 hbar*.

Number of wires in conductor	Practical (final) modulus of elasticity (hbar²)	Coefficient of linear expansionf C
7	5900	23.0 x 10°
19	5600	23.0 x 10 6
37	5600	23.0 x 10.6

Note: These values are given for information purposes only.

APPENDIX C

CODE NAMES FOR STANDARD ALUMINIUM ALLOY STRANDED CONDUCTORS

Note: These code names are not an essential part of the standard. They are given for convenience in ordering conductors.

Nominal Aluminum area mm²	Stranding mm	Code name
25	7/2.34	ALMOND
30	7/2.54	CEDAR
40	7/2.95	FIR
50	7/3.30	HAZEL
100	7/4.65	OAK
150	19/3.48	ASH
175	19/3.76	ELM
300	37/3.53	UPAS

APPENDIX D

LAY RATIOS AND STRANDING CONSTANTS FOR NON STANDARD CONSTRUCTION

Number of wires in conductor	Lay ratio										Stranding constants	
	6-wire layer		12-wire layer		18-wire layer		24-wire layer		30-wire layer		Mass	Electrical Resistance
	min	max	min	max	min	max	min	max	min	max		
61	10	17	10	16	10	15	10	14	-	-	62.35	0.01676
91	10	17	10	16	10	15	10	14	10	13	93.26	0.01126

1. GENERAL

1.1 SCOPE

Part 2 of this British Standard applies to aluminium conductors, steel-reinforced foroverhead powertransmission.

1.2 DEFINITIONS

For the purpose of this part of this British Standard the following definitions apply.

Aluminium conductors, steel-reinforced. A conductor consisting of seven or more Aluminium and galvanized steel wires built up in concentric layers. The center wire or wires are of galvanized steel and the outer layer of layers of aluminium.

Diameter. The mean of two measurements at right angles taken at the same cross section.

Direction of lay. The direction of lay is defined as right-hand or left-hand. With right-hand lay, the wires conform to the direction of the central part of the letter S when the conductor is held vertically.

Lay ratio. The ratio of the axial length of a complete turn of the helix formed by an individual wire in a stranded conductor to the external diameter of the helix.

For other definition reference should de made to US 205.

1.3 STANDARD FOR HARD-DRAWN ALUMINIUM WIRES

1.3.1 Resistivity. The resistivity of Aluminium wire depends upon its purity and its physical condition. For the purpose of this British Standard, the maximum value permitted is 2.8264 mw, at 20° C, and this value shall also be used as the standard resistivity for the purpose of calculation.

1.3.2 Density. At a temperature of 20° Cthe density of hard drawn aluminium wire is to betaken as 2.703 gms/cm3.

1.3.3 Coefficient of linear expansion. The coefficient of linear expansion of hard drawn Aluminium is to be taken as 23x 10-61° C.

1.3.4 Constant mass temperature coefficient. At a temperature of 20° C the constant mass temperature coefficient of resistance of hard drawn Aluminium wire. measured between two potential points rigidly fixed to the wire, is taken as 0.004031° C.

1.4 STANDARD FOR GALVANIZED STEEL WIRE

1.4.1 Density. At a temperature of 20° C the density of galvanized steel wire is to betaken as 7.80 g/cm'.

1.4.2 Coefficient of linear expansion. In order to obtain uniformity in calculations, a value of 11.5x 10.4/° C be taken as the value for the coefficient of linear expansion of galvanized steel wires used for the aluminium conductors, steel reinforced.

2. **MATERIAL**

The aluminium wires used in the construction of the conductor shall be material GIE in the H9 condition as specified in BS 2627.

The galvanized steel wires shall be of the standard tensile strength grads given in BS 4565 unless due of the higher tensile strength grades is specified bythe purchaser.

By agreement between the purchaser and the manufacturer a suitable grease may be applied to the center wire, or additionally to wires in specific layers, evenly throughout the length of the conductor.

3. **DIMENSIONS AND CONSTRUCTIONS**

3.1 **STANDARD SIZE OF WIRES**

The Aluminium and Steel wires for the standard constructions covered by this specification shall have the diameters specified in Table 2 and 3 respectively. The diameters of the steel wires shall be measured overthe zinc coating.

3.2 STANDARD SIZES OF ALUMINIUM CONDUCTORS, STEEL REINFORCED.

3.2.1 The sizes of standard Aluminium Conductors, Steel reinforced are given in table 4.

3.2.2 The masses (excluding the mass of grease for corrosion protection) and resistance's may betaken as being in accordance with Table 4.

3.3 JOINTS IN WIRES

3.3.1 Aluminium wires. In aluminium conductors, steel reinforced, containing any number of Aluminium wires, joints in individual Aluminium wires are permitted, in addition to those made in the base rod or wire before final drawing, but no two such joints shall be less than 15 m apart in the complete stranded conductor. Such joints shall be made by resistance or cold pressure bull welding. They are not required to fulfill the mechanical requirements for unjointed wires. Joints made by resistance bull welding shall, subsequent to welding, be annealed over a distance of at least 200mm, on each side of the joint.

3.3.2 Galvanized steel wires. There shall be no joints, except those made in the base rood or wire before final drawing, in steel wires forming the core of an Aluminium Conductor, Steel reinforced, unless the core consists of seven or more galvanized steel wires. In the latter case joints in individual wires are permitted, in addition to those made in the base rod or wire before final drawing, but no two such joints shall be less than 15 m apart in the complete steel core. Joints in galvanized steel wires shall be made by resistance bull welding and shall be protected against corrosion.

3.4 STRANDING

3.4.1 The wires used in the construction of an Aluminium Conductor, Steel reinforced shall, before stranding, satisfy all the relevant requirements of this standard.

3.4.2 The lay ratio of the different layers shall be within the limits given in Table 1.

Notes: It is important to note that lay ratio is now defined as the ratio of the exist length of a complete turn of the helix formed by an individual wire in stranded conductor to the external diameter of the helix.

3.4.3 In all constructions, the successive layers shall have opposite directions of lay, the outermost layer being right handed. The wires in each layer shall be evenly and closely stranded.

3.4.4 In conductors having multiple layers of Aluminium wires. the lay ratio of nay Aluminium layer shall be not greater than the lay ratio of the Aluminium layer immediately beneath it.

3.4.5 Steel wire shall be formed during stranding so that they remain inert when the conductor is cut.

TABLE 1: LAY RATIOS FOR ALUMINIUM CONDUCTORS, STEEL - REINFORCED

Numbers of wires		Ratio of Aluminium to Steel wire diameter	Lay ratios for steel core		Lay ratios for Aluminium layers							
					6-layer wire		12-layer wire		18-layer wire		24-layer wire	
Alu.	Steel		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
6	1	1.000	--	--	10	14	--	--	--	--	--	--
6	7	3.000	13	28	10	14	--	--	--	--	--	--
15	7	1.000	13	28	--	--	10	14	--	--	--	--
18	1	1.000	--	--	10	16	10	14	--	--	--	--
30	7	1.000	13	28	--	--	10	16	10	14	--	--
54	7	1.000	13	28	--	--	10	17	10	16	10	14

3.5 COMPLETED CONDUCTOR

The completed conductor shall be from dirt, and excessive amounts of drawing oil and other foreign deposits.

4. TESTS

4.1 SELECTION OF TEST SAMPLES

4.1.1 Samples for the tests specified in 4.3 shall be taken by the manufacture before standing, from not less than 10% of the individual lengths of Aluminium and galvanized Steel wire which will be included in any one consignment of stranded conductor.

One sample, sufficient to provide one test specimen for each of the appropriate test, shall be taken from each of the selected conductor.

4.1.2 Alternatively, when the purchaser states at the time of ordering that he desires tests to be made in the presence his representative, samples of wire shall be taken from lengths of stranded conductor selected from approximately 10% of the lengths included in anyone consignment.

One sample, sufficient to provide one specimen for each of the appropriate tests, shall be taken from each of an agreed number of wires of the conductor in each of the selected lengths.

4.2 PLACE OF TESTING

Unless otherwise agreed between the purchase and the manufacturer at the time of ordering, all tests shall be made at the manufacturer's works.

4.3 TESTS

4.3.1 Aluminum wires. The test samples of Aluminum wires taken under 4.1.1 shall be subject to the following tests in accordance with BS 2627* and shall meet the requirements of that standard:

Tensile test

Wrapping test.

Resistively test

Test samples of Aluminum wires taken under 4.1.2 shall be subjects to the same tests but in the case of the tensile test the tensile strength of the specimen shall not be less than 95% of the appropriate minimum value specified in BS 2627*.

4.3.2 Steel wires. The test samples of galvanized steel wires taken under 4.1.1 shall be subjected to the following tests in accordance with BS 4565t and shall meet the requirements of that standard.

Determination of stress at 1% elongation.

Tensile test

Torsion test or elongation test as appropriate.

Wrapping test.

Galvanizing test.

The test sample of galvanized steel wires taken under 4.1.2 shall be subjected to the following tests in accordance with BS 4565t.

Determination of Stress at 1%elongation.

Tensile test

Torsion test or elongation test as appropriate.

Wrapping test.

Galvanizing test.

In the case of the tensile test the tensile strength of the specimen shall not be less than 9504 of the appropriate minimum value specified to BS 4565*.

In the case of the elongation test the elongation of the specimen shall be not less than the appropriate minimum value specified in BS 4565* reduced in numerical value by0.5.

In the case of the stress at 1% elongation, torsion, wrapping and galvanizing tests the appropriate requirements of BS 4565* shall be met.

NOTE: Because of the difficulty in straightening samples taken from stranded cores, it is recommended that determination of stress at 1% elongation on samples taken under 4.1.2 be carried out on the center wire only.

4.4 CERTIFICATION OF COMPLIANCE

When the purchaser does not call for tests on wire taken from the stranded conductor the manufacturer shall, if requested, furnish him with a certificate given the results of the tests made on the samples taken in accordance with

TABLE 2:

ALUMINIUM WIRES USED IN THE CONSTRUCTION OF STANDARD ALUMINIUM CONDUCTORS, STEEL REINFORCED

Standard Diameter	Cross sectional Area of stranded diameter wire	Mass Per kms	Standard Resistance at 20° C 12/km	Min. breaking load for standard diameter wire	Standard Diameter
mm	mm^2	kg	n	N	mm
2.36	4.374	11.82	6.461	770	2.36
2.59	5.269	14.24	5.365	906	2.59
2.79	6.114	16.53	4.623	1030	2.79
3.00	7.069	19.11	3.999	1190	3.00
3.18	7.942	21.47	3.559	1310	3.18
3.35	8.814	23.02	3.007	1450	3.30
3.61	10.24	27.67	2.761	1560	3.61
3.86	11.70	31.63	2.415	1870	8.86
4.72	17.50	47.30	1.615	2780	4.72

TABLE 2

STEEL WIRES USED IN THE CONSTRUCTION OF ALUMINIUM CONDUCTORS, GALVANIZED STEEL - REINFORCED (Clauses 6.1, 8.1, 1, 13.2 and A-3.2)

Diameter			CMS Sectional Arm of Nominal Diameter Wire	Mass	Breaking Load, Min	
Nominal	Mitt	Max			Before Stranding	After Stranding
(1)	(2)	(3)	(4)	(5)	(6)	(7)
mm	mm	mm	mm^2	kg/km	kN	kN
1.50	147	1.53	1.767	11.78	2.46	2 34
1.57	1.54	1.60	1.936	15.10	2.70	2.57
1.96	1.92	2.00	3.017	2331	4.20	3.99
2.11	2.07	2.15	1.497	27.27	4.60	4.37
130	2.25	2.35	4 155	32.41	546	5.19
2.59	2.54	2.64	S 269	41.09	6.92	6.57
1 00	2.94	3.06	7 (169	55.13	9.29	8.83
3.18	3.12	3.24	7.942	61.95	10.43	9.91
3.35	3.28	3.42	8.814	68.75	1138	11.00
3.53	3.46	3.60	9.787	76 34	12.86	12.22
4.09	4.01	4.17	13.14	102.48	17.27	164

TABLE 3:

STEEL WIRES USED IN THE CONSTRUCTION OF STANDARD ALUMINIUM CONDUCTORS, CONDUCTORS, STEEL REINFORCED

Standard Diameter	Cross sectional Area of stranded diameter wire	Mass Per kms	1% elongation for standard diameter wire	Standard Diameter
mm	mm2	kg	n	mm
1.57	1.936	15.10	2.280	1.57
2.36	4.374	34.12	4.990	2.36
2.59	5.269	41.09	6.010	2.59
2.79	6.114	47.69	6.970	2.79
3.00	7.069	55.13	0.069	3.00
3.18	7.942	61.95	8.740	3.18
3.06	8.814	68.75	9.700	3.35
3.61	10.24	79.86	11.260	3.61
3.86	11.70	91.28	12.870	3.86

Note: The Values in Columns 2 to 4 are given for information only.

Notes on Table 4:

1. For the basis of calculation of this table. see Appendix A.
2. The sectional area is the of the sectional area of the relevant individual wires.
3. Attention is drawn to the fact that the Aluminium sectional areas of standard conductors covered by this specification are larger than the nominal Aluminium areas by which they are identified. they should not be compared directly wi th conductors manufacture exactly to nominal areas.

APPENDIX A

NOTES ON THE CALCULATION OF TABLE 4

A.1 **Increase in length due to standing.** When straightened out, each wire in any particular layer of a stranded conductor, except the central wire. is longer than the standard conductor, by an amount depending on the lay ratio of that layer.

A.2 **Resistance and mass of conductor.** In Aluminium conductors. steel-reinforced the conductivity of the steel core is neglected and the resistance of the conductor is calculated with reference to the resistance of the Aluminium wires only. The resistance of any length of stranded conductor is the resistance of the same length of any one Aluminium wire multiplied by a constant. asset out in Table 5.

The mass of each wire in a length of stranded Conductor. except the Central wire. will be greater than that of an equal length of straight wire by an amount depending on the lay ratio of the layer (see A.1 above). The total mass of any length of conductor is, therefore. obtained by multiplying the mass of an equal length of strength wire by their appropriate constant set out in Table 5. The masses of the steel core and aluminum wires are calculated separately and added together

In calculating the stranding constants in Table 5. the mean by ratio. i.e. the arithmetic mean of the relevant minimum and maximum values in Table 1, has been for each layer.

A.3 **Calculated breaking load of conductor.** The breaking load of a conductor, in terms of the strengths of the individual component wires. may be taken to be the sum of the strengths of the Aluminium wires calculated from the specified minimum tensile strengths plus the Sum of the strengths of the steel wires calculated from the specified minimum Stress at 1% elongation.

TABLE 5. STRANDING CONSTANTS

Number of wires in conductor		Standing constants		Code Name
		Mass		Electrical Resistance
Aluminium	Steel	Aluminium	Steel	
6	1	6.091	1.000	1.69 2
6	7	6.079	7.032	0.1692
12	7	12.26	7.032	0.08514
18	1	18.34	1.000	0.056 60
20	7	30.67	7.032	0.034 08
54	7	5521	7.032	0.01804

APPENDIX B

NOTE ON MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

The practical moduli of elasticity given below are based on an analysis of the final moduli determined from a large number of short term stress / strain tests and may be taken as applying to conductors stressed between 15% and 50% 01 the breaking load Of the conductor. They may be regarded as being accurate to within +300 h bar*.

The coefficient of linear expansion given below have been calculated from the practical moduli for the aluminum and steel components of the conductors and coefficient of linear expansion of 23.0x 10.2 and 11.5x 10.4/.C. Aluminium and Steel respectively.

APPENDIX C
CODENAMES FOR STANDARD ALUMINIUM CONDUCTORS, STEEL-REINFORCED

NOTE: These code names are not an essential part of the standard. They are given for convenience in ordering conductors.

Nominal Aluminium Area	Stranding		Code Name
	Aluminium	Steel	
mm2	mm	mm	
25	6/2.35	1/2.36	Copier
30	6/2.59	1/2.59	Weasel
40	6/3.00	1/3.09	
50	6/3.35	1/3.35	Rabolt
70	12/2.79	7/2.79	Horse
100	6/4.72	7/1.57	Dog
150	30/2.59	7/2.59	Wolf
150	18/3.35	1/3.35	Dingo
175	30/2.79	7/2.79	Lynx
175	18/3.61	1/3.61	Caracal
200	30/3.00	7/3.00	Panther
20	18/3.89	1/3.86	Jaguar
400	54/3.10	7/3.18	Zebra

Al 59 Conductor

Application:

Power transmission and distribution lines that operate across a wide voltage range, from low to ultra-high voltage, frequently use AL-59 alloy conductors. Because of their low DC resistance, these conductors are made to carry more current and have less losses. Furthermore, they are especially well-suited for installation in coastal regions and other settings with high humidity or saline exposure because to their exceptional corrosion resistance.

Benefits:

Compared to ACSR of the same size, it has a 26%–31% greater current carrying capacity, lower working tension, and the same maximum sag.

Higher corrosion resistance than 6201 alloy series (AAAC) and significantly lower resistivity than ACSR/AAAC conductors, which results in fewer 12R losses.

AL- 59 ALLOY CONDUCTOR - AS PER SWEDISH STANDARD SS- 4240814

NOMINAL AREA OF AL-59 IN SQMM	STRANDING CONSTRUCTION		Overall Dia (mm) (Approx)	CONDUCTOR WEIGHT kg/km	DC RESISTANCE AT 20°C in Ohms/Km	BREAKING LOAD (KN)
	NO. OF WIRES	WIRE DIAMETER OF INDIVIDUAL WIRE (mm)				
31	7	2.38	7.1	85	0.943	7.77
62	7	3.37	10.1	170	0.47	15.6
99	7	4.25	12.8	271	0.296	22.8
157	19	3.26	16.3	436	0.186	39.7
241	19	4.02	20.1	663	0.123	55.5
329	37	3.37	23.6	910	0.0899	82.5
454	61	3.08	27.7	1260	0.0654	113
593	61	3.52	31.7	1640	0.0501	143
774	61	4.02	36.2	2140	0.0384	178
910	61	4.36	39.2	2520	0.0326	209

HTLS Conductor

HTLS stands for High Tension Low Sag, and HTLS conductors are a type of overhead power line conductor that can operate at higher temperatures with less sag than traditional conductors. They are designed to be more efficient and durable, and can be used to upgrade existing power lines without major infrastructure changes.

High Temperature Low Sag Conductors (HTLS) can withstand operating temperatures of up to 210 °C, thus carrying higher power compared to conventional conductors. These conductors can be applied when there is a need to use an existing OHL that has clearance problems (capacity limitations) and restrictions to the use of new and higher towers. HTLS conductors will allow an increase of the capacity without the need to modify most of the existing towers.

Features of HTLS conductors:

- **Temperature tolerance**

  HTLS conductors can operate at temperatures of up to 250°C or higher, compared to the 90°C to 150°C range for conventional conductors.

- **Low sag**

  HTLS conductors have reduced sag under high temperatures and heavy loads, which helps ensure reliable performance.

- **Increased capacity**

  HTLS conductors have an enhanced current-carrying capacity, which allows for more power transmission.

- **Durability**

  HTLS conductors are made with high-strength materials, which helps ensure long-term stability and reduced maintenance costs.

- **Efficiency**

  HTLS conductors have improved transmission efficiency with lower line losses.

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