AS 3607—1989

Australian Standard®

Conductors—Bare overhead, aluminium and aluminium alloy—Steel reinforced

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PREFACE

This Standard was prepared by the Standards Australia Committee on Overhead Lines to supersede all three parts of AS 1220, *Aluminium conductors steel reinforced for overhead power transmission purposes:*

Part 1: 1973 *Galvanized steel reinforced (ACSR/GZ)*
Part 2: 1973 *Aluminized steel reinforced (ACSR/AZ)*
Part 3: 1973 *Aluminium-clad steel reinforced (ACSR/AC)*

The Standard deals with composite conductors made with aluminium or aluminium alloy wires, reinforced with steel wires. Three types of steel wire are included as alternatives, i.e. zinc-coated (GZ), aluminium-coated (AZ) or aluminium-clad (AC).

In addition, the Standard provides for specific wire sizes in the range 1.60 mm to 4.75 mm, with a range of standard sizes of stranded construction conductors. Furthermore it provides for a range of new conductors containing steel and aluminium alloy wires which reflect actual usage of conductors throughout Australia.

This edition of the Standard differs from AS 1220—1973 as follows:

(a) In determining conductor sizes, a range of wire sizes has been provided similar to the range of wires specified in the 1973 edition, but facility is also provided for conductors with other dimensions to be supplied by reference to this Standard.

(b) To assist users in selecting the most suitable conductor for a particular application, the calculated equivalent aluminium area, conductor breaking load, and d.c. resistance for the standard conductors are given.

(c) Section 2: Wire sizes have been rationalized.

(d) Section 3: The number of standard sizes, especially in the alloy range has been reduced and preferred sizes are indicated.

(e) Section 4: For test purposes, requirements have been added to sequentially identify wire and conductor during production.

(f) Appendix B: Now includes the theoretical basis for the calculation of modulus of elasticity and coefficient of linear expansion.

(g) Appendix E: The code name system has been changed to permit the identification of alloy conductors by reference to existing ACSR code names.

(h) Appendix F: This new Appendix has been included which highlights items which should be specified by the purchaser or agreed between purchaser and manufacturer at the time of order.

In the preparation of this Standard, reference was made to the following Standards:

IEC 207	*Aluminium stranded conductors*
IEC 208	*Aluminium alloy stranded conductors (aluminium-magnesium-silicon)*
IEC 210	*Aluminium alloy conductors, steel reinforced*
IEC 468	*Method of measurement of resistivity of metallic materials*
ASTM B 341	*Aluminium coated (aluminized) steel core wire for aluminium conductors, steel reinforced ACSR/AZ*
ASTM B 498M	*Zinc-coated (galvanized) steel core wire for aluminium conductors, steel reinforced, ACSR (Metric)*
ASTM B 502	*Aluminium-clad steel core wire for aluminium conductors, aluminium-clad steel reinforced*
SS 424 08 13	*Aluminium alloy wire for stranded conductors for overhead lines*

Acknowledgement is made of the assistance received from those sources.

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SECTION 1. SCOPE AND GENERAL

1.1 SCOPE. This Standard specifies requirements and tests for composite bare electrical conductors for overhead power transmission purposes, incorporating aluminium or aluminium alloy wires and steel wires in their construction.

1.2 NOMENCLATURE. Aluminium and aluminium alloy conductors steel reinforced covered by this Standard include the following types, with the code for each in parentheses:

(a) Aluminium 1350, zinc-coated (galvanized) steel reinforced (ACSR/GZ)[2].

(b) Aluminium 1350, aluminium-coated (aluminized) steel reinforced (ACSR/AZ)[2].

(c) Aluminium 1350, aluminium-clad steel reinforced (ACSR/AC)[2].

(d) Aluminium alloy 1120, zinc-coated (galvanized) steel reinforced (AACSR/GZ/1120).

(e) Aluminium alloy 1120, aluminium-coated (aluminized) steel reinforced (AACSR/AZ/1120).

(f) Aluminium alloy 1120, aluminium-clad steel reinforced (AACSR/AC/1120).

(g) Aluminium alloy 6201A, zinc-coated (galvanized) steel reinforced (AACSR/GZ/6201)[3].

(h) Aluminium alloy 6201A, aluminium-coated (aluminized) steel reinforced (AACSR/AZ/6201)[3].

(i) Aluminium alloy 6201A, aluminium-clad steel reinforced (AACSR/AC/6201)[3].

NOTES:

1. A list of code names which may be used to refer to a specific type and construction of conductor is given in Appendix E.
2. An additional suffix may be used, as follows: '/1350' for (a), (b) and (c).
3. The suffix 'A' has been omitted from the conductor code for (g), (h) and (i).

1.3 REFERENCED DOCUMENTS. The following documents are referred to in this Standard:

AS

1391	Methods for tensile testing of metals
1442	Carbon steels and carbon-manganese steels—Hot-rolled bars and semi-finished products
1650	Galvanized coatings
1852	International electrotechnical vocabulary
2505	Methods for bend and related testing of metals
2505.5	Part 5: Torsion and wrapping tests on wire
2848	Aluminium and aluminium alloys—Compositions and designations
2848.1	Part 1: Wrought products
2857	Timber drums for insulated electric cables and bare conductors
C365	Drums for bare stranded conductors
C365.II	Part II: Metal drums

IEC

468	Methods of measurement of resistivity of metallic materials

ASTM

D 566	Dropping point of lubricating grease

1.4 DEFINITIONS. For the purpose of this Standard, the definitions in AS 1852 and those below apply.

1.4.1 Wire—A solid circular component from which stranded conductor is constructed.

1.4.2 King wire—a central core wire having a nominal diameter larger than that of the surrounding wires.

1.4.3 Conductor—a finished circular stranded conductor consisting of seven or more wires laid up together.

1.4.4 Diameter—the mean of two measurements at right angles taken at any one cross-section.

1.4.5 Direction-of-lay—the direction of lay is defined as right-hand or left-hand, as follows:

(a) Right-hand lay—the slope of the wires is in the direction of the central part of the letter Z when the conductor is held vertically.

(b) Left-hand lay—the slope of the wires is in the direction of the central part of the letter S when the conductor is held vertically.

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

1.4.7 Breaking load—the maximum load obtained in a tensile test.

1.4.8 Ultimate tensile stress—the breaking load divided by the original cross-sectional area of the test wire.

1.4.9 Ungreased conductor—a conductor which is dry and free from grease, other than a light residue of wire drawing lubricant that may be on the wires.

1.4.10 Partly greased conductor—a conductor of more than seven wires in which grease is applied only to the steel portion.

1.4.11 Fully greased conductor—a conductor in which grease is applied to all wires with the exception of the outermost layer.

1.4.12 Surface fracture—a crack on the surface of a wire visible to an observer with normal or corrected vision.

1.4.13 Spool—a container of wire which is to be installed on a stranding machine to manufacture the conductor.

SECTION 2. MATERIAL REQUIREMENTS AND WIRE PROPERTIES

2.1 GENERAL The conductor shall be constructed of aluminium or aluminium alloy wires reinforced with steel wires having the properties specified herein.

The conductor may contain grease for additional protection against corrosion.

It is not intended that wires from a conductor purporting to comply with this Standard should be subjected to chemical analysis.

2.2 MATERIALS.

2.2.1 Aluminium and aluminium alloys. The aluminium and aluminium alloys shall comply with the alloy designations 1350, 1120 and 6201A, the compositions of which are specified in AS 2848.1.

2.2.2 Steel.

2.2.2.1 *General.* The base metal for steel reinforcing wire shall be fully-killed steel in accordance with AS 1442. The wire shall be zinc-coated (galvanized-GZ), aluminium-coated (aluminized-AZ) or aluminium-clad (AC).

2.2.2.2 *Zinc-coated steel.* The wire shall be zinc-coated, using either the hot dip or electrolytic process, and the coating shall comply with the relevant requirements of Clause 4.3.1. If the hot-dip galvanizing process is used, the purity of the zinc fed into the bath shall be not less than 98.5 per cent. The wire before coating shall not be copper plated.

2.2.2.3 *Aluminium-coated steel.* The aluminium used for aluminium coating shall conform to the following impurity limits:

Copper 0.10 % max.
Iron 0.50 % max.

The coating shall comply with the relevant requirements of Clause 4.3.2.

2.2.2.4 *Aluminium-clad steel.* The aluminium used for the cladding shall conform to the following impurity limits:

Copper 0.05 % max.
Copper plus silicon plus iron 0.50 % max.

The coating shall comply with the relevant requirements of Clause 4.3.3.

2.2.3 Grease. Grease, used for additional corrosion protection, shall have a drop point of not less than 120°C determined in accordance with ASTM D 566, (see Appendix F).

2.3 WIRE PROPERTIES.

2.3.1 General. Before stranding all wires shall have a round ~~cross-section~~ within the limits specified in Table 2.1. Tables 2.2 to 2.7 list standard wire sizes. For non-standard ~~sizes, the~~ wires shall meet the dimensional tolerances of Table 2.1 and have a minimum ultimate tensile stress corresponding to that of the next larger standard wire size.

Joints in wires shall comply with Clause 3.3. Joints may be made in the base rod or wire before final drawing.

TABLE 2.1
TOLERANCE ON DIAMETER OF WIRES

Material	Standard diameter mm	Tolerance on measurements, with reference to standard diameter: Mean diameter	Ovality (difference between max. and min. at same cross-section)
Aluminium and aluminium alloy	All diameters	±1%	2%
Zinc-coated steel and aluminium-coated steel	≤2.85 >2.85	+3%, −2% ±2%	5% 4%
Aluminium-clad steel	≤2.5 >2.5	±0.04 mm ±1.5%	3% 3%

NOTE: Zinc or aluminium-coated wires, particularly those produced by the hot-dip process, contain inherent surface irregularities. To avoid unjustified rejection of wire that would be satisfactory for use, it is intended that these tolerances be used in gauging the uniform areas of the coated wire.

2.3.2 Aluminium and aluminium alloy wires.

2.3.2.1 *General.* The required properties of standard sizes of aluminium and aluminium alloy wires are given in Tables 2.2 to 2.4 inclusive.

Standard values adopted for the basic properties of aluminium and aluminium alloy wires for the purposes of this Standard are set out in Clauses 2.3.2.2 to 2.3.2.6.

2.3.2.2 *Density.* The density of aluminium and aluminium alloy wire is taken as 2700 kg/m^3 at 20°C.

2.3.2.3 *Resistivity.* The maximum values of resistivity at 20°C of the aluminium and aluminium alloy wires are taken to be:

Aluminium	1350	0.0283 μΩ.m
Aluminium alloy	1120	0.0293 μΩ.m
Aluminium alloy	6201A	0.0328 μΩ.m

2.3.2.4 *Constant-mass temperature coefficients of resistance* (α_{20}). The constant-mass temperature coefficients of resistance of aluminium and aluminium alloy wires at 20°C, measured between two potential points rigidly fixed to the wire, are taken to be:

Aluminium	1350	0.004 03 per °C
Aluminium alloy	1120	0.003 90 per °C
Aluminium alloy	6201A	0.003 60 per °C

2.3.2.5 *Modulus of elasticity.* The modulus of elasticity of aluminium and aluminium alloy wires is taken as 68 GPa.

2.3.2.6 *Coefficient of linear expansion.* The coefficient of linear expansion of aluminium and aluminium alloy wires is taken as 23.0 × 10^{-6} per °C.

TABLE 2.2

PROPERTIES OF ALUMINIUM 1350 WIRES

1	2	3	4	5	6	7	8
Diameter			Cross-sectional area*	Mass per per km*	Minimum breaking load	Minimum ultimate tensile stress	Maximum d.c. resistance per km at 20°C*
Std. mm	Max. mm	Min. mm	mm^2	kg	kN	MPa	Ω
1.75	1.768	1.733	2.405	6.49	0.445	185	11.8
2.50	2.525	2.475	4.909	13.3	0.859	175	5.76
2.75	2.778	2.723	5.940	16.0	1.01	170	4.76
3.00	3.030	2.970	7.069	19.1	1.20	170	4.00
3.25	3.283	3.218	8.296	22.4	1.37	165	3.41
3.50	3.535	3.465	9.621	26.0	1.59	165	2.94
3.75	3.788	3.713	11.04	29.8	1.77	160	2.56
4.75	4.798	4.703	17.72	47.8	2.84	160	1.60

* Tabulated values are based on the standard diameters given in Column 1 and are given for information only.

TABLE 2.3

PROPERTIES OF ALUMINIUM ALLOY 1120 WIRES

1	2	3	4	5	6	7	8
Diameter			Cross-sectional area*	Mass per km*	Minimum breaking load*	Minimum ultimate tensile stress	Maximum d.c. resistance per km at 20°C*
Std. mm	Max. mm	Min. mm	mm^2	kg	kN	MPa	Ω
2.50	2.525	2.475	4.909	13.3	1.23	250	5.97
2.75	2.778	2.723	5.940	16.0	1.49	250	4.93
3.00	3.030	2.970	7.069	19.1	1.77	250	4.14
3.25	3.283	3.218	8.296	22.4	2.07	250	3.53
3.50	3.535	3.465	9.621	26.0	2.31	240	3.05
3.75	3.788	3.713	11.04	29.8	2.65	240	2.65
4.75	4.798	4.703	17.72	47.8	4.08	230	1.65

* Tabulated values are based on the standard diameter given in Column 1 and are given for information only.

2.3.3 Steel wires.

2.3.3.1 *General.* The required properties of standard steel wires are given in Tables 2.5, 2.6 and 2.7.

Standard values adopted for the basic properties of steel wires for the purposes of this Standard are set out in Clauses 2.3.3.2 to 2.3.3.6.

2.3.3.2 *Density.* The density of steel wire at 20°C is taken to be:

Zinc-coated (GZ) 7800 kg/m³
Aluminium-coated (AZ) 7600 kg/m³
Aluminium-clad (AC) 6590 kg/m³

2.3.3.3 *Resistivity.* The resistivity of steel wire varies considerably with steel quality, tensile strength, and coating/cladding thickness. Maximum values at 20°C are taken to be:

Zinc-coated (GZ) 0.17 μΩ.m
Aluminium-coated (AZ) 0.15 μΩ.m
Aluminium-clad (AC) 0.085 μΩ.m

2.3.3.4 *Constant-mass temperature coefficient of resistance* (α_{20}). The constant-mass temperature coefficient of resistance of steel wire at 20°C, measured between two potential points rigidly fixed to the wire, are taken to be:

Zinc-coated (GZ) 0.0044 per °C
Aluminium-coated (AZ) 0.0044 per °C
Aluminium-clad (AC) 0.0036 per °C

2.3.3.5 *Modulus of elasticity.* The modulus of elasticity of steel wire is taken to be:

Zinc-coated (GZ) 193 GPa
Aluminium-coated (AZ) 193 GPa
Aluminium-clad (AC) 162 GPa

2.3.3.6 *Coefficient of linear expansion.* The coefficient of linear expansion is taken to be:

Zinc-coated (GZ) 11.5×10^{-6} per °C
Aluminium-coated (AZ) 11.5×10^{-6} per °C
Aluminium-clad (AC) 12.9×10^{-6} per °C

TABLE 2.4

PROPERTIES OF ALUMINIUM ALLOY 6201A WIRES

1	2	3	4	5	6	7	8
Diameter			Cross-sectional area*	Mass per km*	Minimum breaking load*	Minimum ultimate tensile stress	Maximum d.c. resistance per km at 20°C*
Std. mm	Max. mm	Min. mm	mm²	kg	kN	MPa	Ω
3.00	3.030	2.970	7.069	19.1	2.09	295	4.64
3.50	3.535	3.465	9.621	26.0	2.84	295	3.41
3.75	3.788	3.713	11.04	29.8	3.26	295	2.97
4.75	4.798	4.703	17.72	47.8	5.23	295	1.85

* Tabulated values are based on the standard diameters given in Column 1 and are given for information only.

TABLE 2.5

PROPERTIES OF ZINC-COATED STEEL (GZ) WIRES

1	2	3	4	5	6	7	8
Diameter			Cross-sectional area*	Mass per km*	Minimum breaking load*	Minimum ultimate tensile stress	Maximum d.c. resistance per km at 20°C*
Std. mm	Max. mm	Min. mm	mm²	kg	kN	MPa	Ω
1.60	1.648	1.568	2.011	15.7	2.80	1390	85
1.75	1.803	1.715	2.405	18.8	3.34	1390	71
2.25	2.318	2.205	3.976	31.0	5.21	1310	43
2.50	2.575	2.450	4.909	38.3	6.43	1310	35
2.75	2.833	2.695	5.940	46.3	7.78	1310	29
3.00	3.060	2.940	7.069	55.1	9.26	1310	24
3.25	3.315	3.185	8.296	64.7	10.9	1310	20
3.50	3.570	3.430	9.621	75.0	12.6	1310	18
3.75	3.825	3.675	11.04	86.1	14.5	1310	15

* Tabulated values are based on the standard diameters given in Column 1 and are given for information only.

TABLE 2.6

PROPERTIES OF ALUMINIUM-COATED STEEL (AZ) WIRES

1	2	3	4	5	6	7	8
Diameter			Cross-sectional area*	Mass per km*	Minimum breaking load*	Minimum ultimate tensile stress	Maximum d.c. resistance per km at 20 °C*
Std. mm	Max. mm	Min. mm	mm^2	kg	kN	MPa	Ω
1.60	1.648	1.568	2.011	15.3	2.57	1280	75
2.50	2.575	2.450	4.909	37.3	6.09	1240	31
3.00	3.060	2.940	7.069	53.7	8.77	1240	21
3.75	3.825	3.675	11.04	83.9	12.9	1170	14

* Tabulated values are based on the standard diameters given in Column 1, and are given for information only.

TABLE 2.7

PROPERTIES OF ALUMINIUM-CLAD STEEL (AC) WIRES

1	2	3	4	5	6	7	8
Diameter			Cross-sectional area*	Mass per km*	Minimum breaking load*	Minimum ultimate tensile stress	Maximum d.c. resistance per km at 20 °C*
Std. mm	Max. mm	Min. mm	mm^2	kg	kN	MPa	Ω
1.60	1.640	1.560	2.011	13.3	2.69	1340	42.3
1.75	1.790	1.710	2.405	15.8	3.22	1340	35.3
2.25	2.290	2.210	3.976	26.2	5.33	1340	21.4
2.50	2.540	2.460	4.909	32.4	6.58	1340	17.3
2.75	2.791	2.709	5.940	39.1	7.96	1340	14.3
3.00	3.045	2.955	7.069	46.6	9.47	1340	12.0
3.25	3.299	3.201	8.296	54.7	11.1	1340	10.2
3.50	3.553	3.448	9.621	63.4	12.6	1310	8.83
3.75	3.806	3.694	11.04	72.8	14.0	1270	7.70

* Tabulated values are based on the standard diameters given in Column 1, and are given for information only.

SECTION 3. CONDUCTOR REQUIREMENTS

3.1 CONSTRUCTION.

3.1.1 General. The wire used in the construction of an aluminium or aluminium alloy conductor, steel reinforced, shall, before stranding, comply with the requirements of Section 2 of this Standard.

Conductors having more than one steel wire shall consist of a central steel wire with the other steel wires equally spaced circumferentially in the next layer.

No aluminium-coated steel wire shall be used in the outer layer of a conductor.

All wires in a conductor shall lie naturally in their correct positions. They shall tend to remain in position when the conductor is cut at any point, and shall permit restranding by hand after being forcibly unravelled.

3.1.2 King wire. A king wire may be included in the conductor (see Appendix F). The size of the king wire shall be five percent greater in diameter than that of the surrounding wires. This wire shall meet the mechanical and electrical properties of the other steel wires.

3.1.3 Grease. Additional protection against corrosion may be provided by the application of a grease (see Appendix F).

3.2 IDENTIFICATION OF ALUMINIUM ALLOY CONDUCTORS. Conductors manufactured to this Standard from either 1120 or 6201A alloys may be identified by means of a coloured thread, incorporated within the conductor, to signify the aluminium alloy employed. The thread shall be of durable non-hygroscopic material and coloured as follows: 1120—blue, 6201A—red (see Appendix F).

3.3 JOINTS IN WIRES OF CONDUCTORS.

3.3.1 General. All joints made during the stranding operation shall be in accordance with Clauses 3.3.2 and 3.3.3. They shall be free from visible defects but are not required to fulfil the mechanical requirements of unjointed wires.

3.3.2 Conductors containing seven wires. For conductors containing seven wires, the requirements for joints are as follows:

(a) *Aluminium or aluminium alloy wires.* Joints in aluminium or aluminium alloy wires shall be made only by cold-pressure butt-welding. The minimum distance between any two joints in the conductor shall be 15 m.

(b) *Steel wires.* There shall be no joint in any steel wire.

3.3.3 Conductors containing more than seven wires. For conductors containing more than seven wires, the requirements for joints are as follows:

(a) *Aluminium or aluminium alloy wires.* Joints in aluminium and aluminium alloy wires shall be made by cold-pressure butt-welding or resistance butt-welding. Joints made by resistance butt-welding shall be annealed after welding over a distance of at least 200 mm on each side of the joint. The minimum distance between any two joints in the conductor shall be 15 m.

(b) *Steel wires.* Joints in steel wires shall be made by resistance butt-welding and shall be protected against corrosion. The minimum distance between any two joints in the conductor shall be 15 m.

3.4 LAY.

3.4.1 Lay ratio. The lay ratio of the different layers shall be within the limits given in Table 3.1.

3.4.2 Direction of lay. 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 STANDARD SIZES AND CALCULATED PROPERTIES OF CONDUCTORS. The standard sizes and calculated properties of aluminium and aluminium alloy conductors steel reinforced are given in Tables 3.2 to 3.4.

Code names by which the individual conductors may be referred to are listed in Appendix E.

TABLE 3.1
LAY RATIOS FOR ALUMINIUM AND ALUMINIUM ALLOY CONDUCTORS, STEEL REINFORCED

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of wires		Lay ratio of steel core				Lay ratio of aluminium or aluminium alloy layers							
Aluminium or aluminium alloy	Steel	6-wire layer		12-wire layer		6-wire layer		12-wire layer		18-wire layer		24-wire layer	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
3	4	12*	18*	—	—	—	—	—	—	—	—	—	—
4	3	12*	18*	—	—	—	—	—	—	—	—	—	—
6	1	—	—	—	—	10	14	—	—	—	—	—	—
6	7	13	28	—	—	10	14	—	—	—	—	—	—
18	1	—	—	—	—	10	16	10	14	—	—	—	—
30	7	13	28	—	—	—	—	10	16	10	14	—	—
54	7	13	28	—	—	—	—	10	17	10	16	10	14
54	19	13	28	12	24	—	—	10	17	10	16	10	14

* The lay ratios for 3/4 and 4/3 strandings are those for the composite conductor.

TABLE 3.2

STANDARD SIZES AND CALCULATED PROPERTIES OF STEEL-REINFORCED ALUMINIUM 1350 CONDUCTORS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Stranding and wire diameter				Zinc-coated steel reinforced conductor ACSR/GZ/1350				Aluminium-coated steel reinforced conductor ACSR/AZ/1350				Aluminium-clad steel reinforced conductor ACSR/AC/1350			
Aluminium 1350 mm	Steel mm	Nominal overall diameter mm	Cross-sectional area mm²	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20°C Ω	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20°C Ω	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20°C Ω
6/2.50	1/2.50	7.5	34.36	119	10.5	29.0	0.975	118	10.2	29.0	0.975	113	10.6	30.7	0.923
6/2.75	1/2.75	8.3	41.58	144	12.6	35.1	0.805	—	—	—	—	137	12.7	37.1	0.763
6/3.00	1/3.00	9.0	49.48	171	14.9	41.8	0.677	170	14.5	41.8	0.677	163	15.1	44.1	0.641
6/3.75	1/3.75	11.3	77.31	268	22.7	65.2	0.433	265	21.4	65.2	0.433	254	22.3	68.9	0.410
6/4.75	7/1.60	14.3	120.4	402	33.4	105	0.271	399	32.0	105	0.271	385	32.7	109	0.259
30/2.50	7/2.50	17.5	181.6	677	63.5	144	0.196	—	—	—	—	636	64.4	155	0.182
30/3.00	7/3.00	21.0	261.5	973	90.4	207	0.136	—	—	—	—	913	91.6	224	0.126
30/3.25	7/3.25	22.8	306.9	1140	105	243	0.116	—	—	—	—	1070	106	263	0.108
30/3.50	7/3.50	24.5	356.0	1320	122	282	0.100	—	—	—	—	1240	122	305	0.0928
54/3.00	7/3.00	27.0	431.2	1440	119	373	0.0758	—	—	—	—	1380	120	390	0.0726
54/3.25	7/3.25	29.3	506.0	1690	137	438	0.0646	—	—	—	—	1620	139	457	0.0619
54/3.50	7/3.50	31.5	586.9	1960	159	508	0.0557	—	—	—	—	1880	159	530	0.0533
54/3.75	19/2.25	33.8	672.0	2240	178	583	0.0485	—	—	—	—	2150	180	608	0.0465
3/1.75	4/1.75	5.3	16.84	95	12.7	8.74	3.25	—	—	—	—	83	12.3	10.3	2.75
3/2.50	4/2.50	7.5	34.36	195	24.4	17.8	1.59	—	—	—	—	171	24.9	21.1	1.34
4/3.00	3/3.00	9.0	49.48	243	28.3	31.5	0.897	—	—	—	—	218	28.9	35.0	0.807
4/3.75	3/3.75	11.3	77.31	380	43.9	49.2	0.573	—	—	—	—	340	42.6	54.7	0.517

NOTES:

1. Preferred conductors are shown in bold type.
2. The cross-sectional area is the sum of the cross-sectional areas of the relevant individual wires.
3. Properties shown are calculated in accordance with the methods of Appendix A and are given for information purposes only.
4. Tabulated values given are based on standard diameters.

TABLE 3.3
STANDARD SIZES AND CALCULATED PROPERTIES OF STEEL-REINFORCED ALUMINIUM ALLOY 1120 CONDUCTORS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Stranding and wire diameter				Zinc-coated steel reinforced conductor AACSR/GZ/1120				Aluminium-coated steel reinforced conductor AACSR/AZ/1120				Aluminium-clad steel reinforced conductor AACSR/AC/1120			
Aluminium alloy 1120 mm	Steel mm	Nominal overall diameter mm	Cross-sectional area mm²	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20 °C Ω	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20 °C Ω	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20 °C Ω
6/3.00	**1/3.00**	9.0	**49.48**	171	18.3	40.3	**0.700**	**170**	17.9	40.3	**0.700**	163	18.4	42.7	0.662
6/3.75	1/3.75	11.3	77.31	268	27.9	63.0	0.448	265	26.5	63.0	0.448	254	27.6	66.7	0.424
6/4.75	**7/1.60**	**14.3**	**120.4**	**402**	**40.7**	**101**	**0.279**	**399**	**39.3**	**101**	**0.279**	**385**	**40.0**	**106**	**0.267**
18/3.50	**1/3.50**	**17.5**	**182.8**	**552**	**51.5**	**164**	**0.173**	—	—	—	—	**540**	**51.5**	**167**	**0.169**
30/2.50	7/2.50	17.5	181.6	677	74.4	139	0.203	—	—	—	—	636	75.2	151	0.188
30/3.00	**7/3.00**	**21.0**	**261.5**	**973**	**107**	**200**	**0.141**	—	—	—	—	**913**	**108**	**217**	**0.130**
30/3.25	7/3.25	22.8	306.9	1140	126	235	0.120	—	—	—	—	1070	127	254	0.111
30/3.50	**7/3.50**	**24.5**	**356.0**	**1320**	**143**	**273**	**0.104**	—	—	—	—	**1240**	**143**	**295**	**0.0961**
54/3.00	**7/3.00**	**27.0**	**431.2**	**1440**	**149**	**360**	**0.0784**	—	—	—	—	**1380**	**150**	**377**	**0.0750**
54/3.25	7/3.25	29.3	506.0	1690	174	423	0.0669	—	—	—	—	1620	176	442	0.0639
54/3.50	**7/3.50**	**31.5**	**586.9**	**1960**	**197**	**491**	**0.0578**	—	—	—	—	**1880**	**197**	**513**	**0.0552**

NOTES:

1. Preferred conductors are shown in bold type.
2. The cross-sectional area is the sum of the cross-sectional areas of the relevant individual wires.
3. Properties shown are calculated in accordance with the methods of Appendix A and are given for information purposes only.
4. Tabulated values given are based on standard diameters.

TABLE 3.4

STANDARD SIZES AND CALCULATED PROPERTIES OF STEEL REINFORCED ALUMINIUM ALLOY 6201A CONDUCTORS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Stranding and wire diameter				Zinc-coated steel reinforced conductor AACSR/GZ/6201A				Aluminium-coated steel reinforced conductor AACSR/AZ/6201A				Aluminium-clad steel reinforced conductor AACSR/AC/6201A			
Aluminium alloy 6201A mm	Steel mm	Nominal overall diameter mm	Cross-sectional area mm²	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20°C Ω	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20°C Ω	Approx. mass kg/km	Break. load kN	Equiv. aluminium area mm²	d.c. resistance per km at 20°C Ω
6/3.00	1/3.00	9.0	49.48	171	20.2	36.0	0.785	170	19.7	36.0	0.785	163	20.3	38.4	0.737
6/3.75	1/3.75	11.3	77.31	268	31.5	56.3	0.503	265	30.1	56.3	0.503	254	31.1	60.0	0.472
6/4.75	7/1.60	14.3	120.4	402	47.4	90.4	0.313	399	46.0	90.4	0.313	385	46.8	95.0	0.298
18/3.50	1/3.50	17.5	182.8	552	60.8	147	0.193	—	—	—	—	540	60.8	149	0.189
30/3.00	7/3.00	21.0	261.5	973	117	179	0.158	—	—	—	—	913	118	195	0.145
30/3.50	7/3.50	24.5	356.0	1320	158	244	0.116	—	—	—	—	1240	158	266	0.106

NOTES:

1. The cross-sectional area is the sum of the cross-sectional areas of the relevant individual wires.
2. Properties shown are calculated in accordance with the methods of Appendix A and are given for information purposes only.
3. Tabulated values given are based on standard diameters.

SECTION 4. TESTS

4.1 SELECTION OF TEST SPECIMENS.

4.1.1 General. This Standard requires testing of component wires only. The wires shall be tested before stranding under a routine test procedure (see Clause 4.1.2).

Special tests may be carried out (see Clause 4.1.3) on specimens of wire taken from a sample of conductor (see Appendix F).

4.1.2 Routine tests. Routine tests shall be conducted on a specimen taken from every tenth spool of wire prepared for loading on a stranding machine and shall be tested as specified in Table 4.1.

If a sample fails a test, that test shall be repeated on two further specimens taken from the same spool. If either of these fail, the spool shall be rejected and five spools produced sequentially, before and after the rejected spool shall be individually tested.

4.1.3 Special tests. Special tests shall be conducted on wire specimens taken from a sample length of conductor from either one drum in every 200 km of conductor produced, or from one drum from every production run, whichever rate provides the largest number of samples.

Specimens shall be tested as specified in Table 4.2.

If a specimen fails a test, that test shall be repeated on a further sample of conductor taken from the same drum. If any of the wire specimens fail the retest, the drum shall be rejected, and the drum of conductor produced immediately before and the drum of conductor produced immediately after the rejected drum shall be individually tested.

4.2 MECHANICAL TESTS.

4.2.1 Dimensions. The diameter of the wire shall be measured and recorded and shall be within the limits specified in Clause 2.3.1, and where applicable in Tables 2.2 to 2.7.

4.2.2 Ultimate tensile stress test. The breaking load of each specimen, selected in accordance with Clause 4.1 shall be determined in accordance with the method given in AS 1391. The ultimate tensile stress shall be calculated on the basis of the actual cross-sectional area of the wire before testing.

For routine tests the ultimate tensile stress of the specimen shall be not less than the appropriate value given in Tables 2.2 to 2.7 inclusive.

For special tests, the ultimate tensile stress of the specimen shall be not less than 95 percent of the appropriate value given in Tables 2.2 to 2.7 inclusive.

The test specimen shall be free from bends or kinks other than the curvature resulting from the usual spooling or stranding operation.

4.2.3 Ultimate elongation test. Where specified in Tables 4.1 and 4.2, the ultimate elongation shall be determined by suitably measuring the increase in distance between the gauge marks, after carefully fitting the broken ends of the test specimen together, in accordance with the method given in AS 1391.

The elongation on a gauge length of 250 mm shall be not less than the appropriate values given in Table 4.3.

4.2.4 Torsion test. The torsion test shall be carried out in accordance with AS 2505.5 except as modified herein. The specimens of wire selected in accordance with Clause 4.1 shall each be gripped at the ends in two vices, one of which shall be free to move longitudinally during the test. A small tensile force, not exceeding 2 percent of the breaking load of the wire, may be applied to the sample during testing. The specimen shall be twisted by causing one of the vices to revolve until breakage occurs and the number of twists shall be indicated by a counter or other suitable device. The rate of twisting shall not exceed 60 turns per minute.

The number of complete twists before breakage occurs shall be not less than the values given in Table 4.4.

TABLE 4.1
SCHEDULE OF ROUTINE TESTS

Test	Clause reference	Aluminium 1350	Aluminium alloy 1120	Aluminium alloy 6201A	Zinc-coated steel	Aluminium-coated steel	Aluminium-clad steel
Dimensions	4.2.1	100	100	100	100	100	100
Ultimate tensile stress	4.2.2	100	100	100	100	100	100
Ultimate elongation	4.2.3	P10	P10	P10	A	A	A
Torsion	4.2.4	N/A	N/A	N/A	A	A	A
Wrapping	4.2.5	10	10	10	10	10	N/A
Coating	4.3	N/A	N/A	N/A	10	10	10
Resistivity	4.4	10	10	10	N/A	N/A	10

LEGEND:

100 = Tests to be conducted on 100% of specimens selected in accordance with Clause 4.1.2.

10 = Tests to be conducted on not less than 10% of specimens selected in accordance with Clause 4.1.2.

A = Ultimate elongation or torsion tests as alternative tests, to be conducted on not less than 10% of specimens selected in accordance with Clause 4.1.2.

P10 = Optional tests to be carried out on not less than 10% of specimens selected in accordance with Clause 4.1.2

N/A = Not applicable.

TABLE 4.2
SCHEDULE OF SPECIAL TESTS

Test	Clause reference	Aluminium 1350	Aluminium alloy 1120	Aluminium alloy 6201A	Zinc-coated steel	Aluminium-coated steel	Aluminium-clad steel
Dimensions	4.2.1	100	100	100	100	100	100
Ultimate tensile stress	4.2.2	100	100	100	100	100	100
Ultimate elongation	4.2.3	N/A	N/A	N/A	A	A	A
Torsion	4.2.4	N/A	N/A	N/A	A	A	A
Wrapping	4.2.5	10	10	10	10	10	N/A
Coating	4.3	N/A	N/A	N/A	10	10	10
Resistivity	4.4	10	10	10	N/A	N/A	10

LEGEND:
- 100 = Tests to be conducted on 100% of specimens selected in accordance with Clause 4.1.3.
- 10 = Tests to be conducted on not less than 10% of specimens selected in accordance with Clause 4.1.3.
- A = Ultimate elongation or torsion tests as alternative tests, to be conducted on not less than 10% of specimens selected in accordance with Clause 4.1.3.
- N/A = Not applicable.

TABLE 4.3
ULTIMATE ELONGATION OF WIRES

Material	Minimum ultimate percentage elongation in 250 mm, for wires of specified diameter range			
	>1.5 ≤2.50 mm	>2.50 ≤3.25 mm	>3.25 ≤4.00 mm	>4.00 ≤4.75 mm
Aluminium 1350	0.8	1.0	1.2	1.4
Aluminium alloy 1120	0.8	1.0	1.2	1.4
Aluminimum alloy 6201A	—	3.0	3.0	3.0
Zinc-coated steel (GZ)*	3.0	3.5	4.0	4.0
Aluminium-coated steel (AZ)	3.0	3.5	4.0	4.0
Aluminium-clad steel (AC)	1.0	1.0	1.3	1.5

* Elongation tests are not appropriate for wires drawn after zinc coating.

TABLE 4.4
MINIMUM TORSION REQUIREMENT FOR STEEL WIRES

Wire condition	Minimum number of twists to breakage on a length of 100 times the wire diameter		
	Zinc-coated (GZ)	Aluminium-coated (AZ)	Aluminium-clad (AC)
Before stranding	18	18	20
After stranding	16	16	20

NOTE: The test length may be varied from 100 times the wire diameter, in which case the number of twists to breakage shall be adjusted *pro rata*. The calculated number of twists to breakage shall be a whole number, with fractions of a twist to be taken as one twist.

4.2.5 Wrapping test. The wrapping test shall be carried out in accordance with AS 2505.5 except as modified herein. The specimens of wire selected in accordance with Clause 4.1 shall each be wrapped around a wire of its own diameter to form a close helix of eight turns. The wrapping rate shall not exceed 60 turns per minute. Where applicable the specimens shall be unwrapped and rewrapped, according to the schedule specified in Table 4.5. The wire shall meet the acceptance criteria of Table 4.5.

TABLE 4.5

WRAPPING TEST REQUIREMENTS

Material	Test schedule number of turns			Acceptance criterion
	On	Off	On	
Zinc-coated steel (GZ)	8	7	—	Shall not break
Aluminium-coated steel (AZ)	8	7	—	Shall not break
Aluminium-clad steel (AC)	N/A	N/A	N/A	
Aluminium 1350	8	6	6	Shall not break
Aluminium alloy 1120	8	—	—	No surface fracture
Aluminium alloy 6201A	8	—	—	No surface fracture

N/A = Not applicable.

4.3 COATING TESTS.

4.3.1 Zinc-coated wire. Coating tests shall be made on specimens of wire selected in accordance with Clause 4.1.

The mass, quality and adherence of the zinc coating whether applied by the hot dip or the electrolytic process shall be tested in accordance with AS 1650.

The mass of coating shall be not less than that specified in Table 4.6.

TABLE 4.6

MASS OF ZINC COATING FOR STEEL WIRES

Nominal diameter of coated wire mm		Minimum coating mass g/m^2
⩾ 1.55	⩽ 1.80	200
> 1.80	⩽ 2.24	215
> 2.24	⩽ 2.72	230
> 2.72	⩽ 3.15	240
> 3.15	⩽ 3.55	250
> 3.55	⩽ 4.25	260

4.3.2 Aluminium-coated wire.

4.3.2.1 *General.* Coating tests as prescribed in Clauses 4.3.2.2 to 4.3.2.4 shall be made on specimens of wire selected in accordance with Clause 4.1.

4.3.2.2 *Adherence of coating.* The wire shall be capable of being wrapped in a close helix at a rate not exceeding 15 turns per minute around a cylindrical steel mandrel having a diameter as prescribed in Table 4.7, without cracking or flaking the aluminium coating.

NOTE: Loosening or detachment during the adherence test of superficial small particles of aluminium formed by mechanical polishing of the surface of aluminium coated wire is not considered cause for rejection.

TABLE 4.7

MANDREL SIZE FOR ADHERENCE TEST FOR ALUMINIUM-COATED WIRES

Standard diameter of aluminium-coated wire mm	Ratio of mandrel diameter to wire diameter
⩾1.60 ⩽2.25	3
>2.25 ⩽3.50	4
>3.50	5

4.3.2.3 *Continuity of coating.* Testing wire for continuity of the aluminium coating may be carried out using the method given in Appendix C (see Appendix F).

4.3.2.4 *Mass of coating.* The mass of aluminium coating on the steel wire shall be determined by the method described in Appendix D and shall conform with the values given in Table 4.8.

TABLE 4.8

MINIMUM MASS OF ALUMINIUM COATING FOR STEEL WIRES*

Wire diameter mm	Minimum mass of aluminium coating g/m^2
1.60	77
2.25	80
2.50	86
3.00	92
3.50	98
3.75	104

* Wire with diameter intermediate to those shown shall have a coating mass equal to the next larger size.

4.3.3 Aluminium-clad wire. Measurement of the radial thickness of the aluminium cladding shall be made on each of the specimens of aluminium-clad wire selected in accordance with Clause 4.1.

Measurement to an accuracy of 0.02 mm shall be made by cutting off suitable specimens, preparing and etching the cross-section and measuring with an optical instrument or by using a suitable indicating instrument.

The radial thickness of aluminium cladding at any point on the wire shall be not less than five percent of the standard diameter of the aluminium-clad steel wire.

4.4 RESISTIVITY TEST. The specimens of aluminium, aluminium alloy and aluminium-clad steel wire selected in accordance with Clause 4.1 shall each be measured for electrical resistance in accordance with the method given in IEC 468 to an accuracy of at least one part in a thousand at a temperature of not less than 10°C nor more than 30°C. The length of the specimen shall be sufficient to give the accuracy required and shall be suitable for the method of testing used.

The value of resistance, measured at a temperature of T(°C), shall be corrected to that at 20°C, by multiplying the measured value by a correction factor (K), given by:

$$K = \frac{1}{1 + \alpha_{20}(T - 20)}$$

where

α_{20} is the appropriate constant mass temperature coefficient of resistance, as per Clauses 2.3.2.4 and 2.3.3.4.

The resistivity shall be calculated from the corrected resistance, and its value shall not exceed the values given in Clause 2.3.2.3 or Clause 2.3.3.3, as appropriate.

4.5 LAY RATIO. The lay ratios shall be checked and recorded at the beginning and end of each production run of any one size of conductor, by measuring the lays with the conductor under tension on the stranding machine.

The lay ratios shall be within the appropriate limits specified in Table 3.1.

4.6 PLACE OF TESTING. All tests shall be made at the manufacturer's works.

4.7 INSPECTION. Inspection shall be made at the manufacturer's works.

4.8 TEST CERTIFICATE. The manufacturer shall supply the purchaser with either a certificate giving the results of tests made on the specimens selected in accordance with Clause 4.1, or a written statement that the conductor complies with this Standard.

SECTION 5. PACKING AND MARKING

5.1 PACKING. The conductor shall be supplied on drums constructed to the requirements of AS 2857 or AS C365, Part II.

5.2 MARKING. The following information shall be legibly and durably marked on the flange of the drum or on a label:

(a) Manufacturer's name.

(b) Manufacturer's drum serial number.

(c) Size and type of conductor.

(d) Whether conductor is ungreased, partially greased or wholly greased.

(e) Length of conductor.

(f) Gross mass of drum and conductor.

(g) Handling or lifting instructions where such handling or lifting is by means other than a spindle through the spindle holes with spreader to prevent damage to flanges.

(h) An arrow with the words 'ROLL THIS WAY' to indicate the direction in which the drum should be rolled on the flanges.

NOTES:

1. An acceptable means of marking all or part of the above information would be a waterproof plate or label securely attached to the drum (see Appendix F).

2. Manufacturers making a statement of compliance with this Australian Standard on a product, or on packaging or promotional material related to that product, are advised to ensure that such compliance is capable of being verified.

   Independent certification is available from Standards Australia under the StandardsMark Product Certification Scheme. The StandardsMark, shown below, is a (registered) certification trade mark owned by Standards Australia and granted under licence to manufacturers whose products comply with the requirements of suitable Australian Standards and who operate sound quality assurance programs to ensure consistent product quality.

   Further information on product certification and the suitability of this Standard for certification is available from Standards Australia's Quality Assurance Services, 80 Arthur Street, North Sydney, N.S.W., 2060.

APPENDIX A

CALCULATION OF CONDUCTOR PROPERTIES

(This Appendix does not form an integral part of this Standard.)

A1 GENERAL. The values given in Tables 3.2 to 3.4 inclusive and in this Appendix are based on standard diameters and are given for information purposes only. Tests for these properties do not form part of the requirements of this Standard.

A2 INCREASE IN LENGTH DUE TO STRANDING. When straightened, each wire in any particular layer of a conductor, except the central wire, is longer than the conductor by an amount depending on the mean lay ratio of that layer as derived from Table 3.1.

NOTE: The mean lay ratio is the arithmetic mean of the relevant maximum and minimum values given in Table 3.1.

A3 MASS OF CONDUCTOR. The mass of each wire in a length of conductor, except the central wire, will be greater than that of an equal length of straight wire by an amount depending on the mean lay ratio of the layer as derived from Table 3.1. The total mass of an aluminium or aluminium alloy conductor, steel reinforced, is obtained by calculating the mass of the aluminium or aluminium alloy and steel wires separately, and adding them together. The mass of each component material is obtained by multiplying the mass of an equal length of straight wire by its respective mass constant set out in Table A1.

A4 DIRECT CURRENT RESISTANCE OF CONDUCTOR.

A4.1 General. The resistance of any length of a conductor is obtained by multiplying the resistance of an equal length of straight wire by its respective resistance constant set out in Table A1.

A4.2 Resistance, conductor types: (ACSR/GZ), (AACSR/GZ). For conductor of 3/4 and 4/3 construction, because of the high proportion of steel in the conductor, the resistance is calculated as in Clause A4.4.

For other conductors, the resistance is calculated with reference to the resistance of the aluminium or aluminium alloy wires only. The conductivity of the zinc-coated steel wire(s) is not taken into account.

A4.3 Resistance, conductor types: (ACSR/AZ), (AACSR/AZ). The resistance of the conductor is calculated with reference to the aluminium or aluminium alloy wires only. The conductivity of the aluminium coated steel wire(s) is not taken into account.

A4.4 Resistance, conductor types: (ACSR/AC), (AACSR/AC). The resistance of the conductor is obtained by taking the resistance of the aluminium or aluminium alloy wires, and the aluminium-clad steel separately. The parallel equivalent resistance of the two components is then calculated.

A5 EQUIVALENT ALUMINIUM AREA.

A5.1 General. The term 'equivalent aluminium area' denotes the area of a solid aluminium 1350 rod which would have the same resistance as the conductor. This area takes into account the assumed increase of resistance of each wire except the central wire (see Paragraph A2 above), and any differences in resistivity between the component materials of the conductor and aluminium 1350. The equivalent aluminium area of a conductor is the sum of the areas of the appropriate component wires.

A5.2 Aluminium and aluminium alloy. The equivalent aluminium area of the aluminium or aluminium alloy is obtained by multiplying the area of one wire by—

(a) the appropriate area constant set out in Table A1;

and in the case of aluminium alloy wires by—

(b) the ratio of the resistivity of aluminium 1350 to that of the aluminium alloy (see Clause 2.3.2.3).

A5.3 Zinc-coated steel. The equivalent aluminium area of the zinc-coated steel is taken into account only for conductors of 3/4 and 4/3 construction (see Paragraph A4 above).

A5.4 Aluminium-coated steel. The equivalent aluminium area of the aluminium-coated steel is not taken into account.

A5.5 Aluminium-clad steel. The equivalent aluminium area of the aluminium-clad steel is obtained by multiplying the area of one wire by both—

(a) the appropriate area constant set out in Table A1; and

(b) the ratio of the resistivity of aluminium 1350 to the resistivity of aluminium-clad steel (see Clause 2.3.3.3).

A6 CALCULATED BREAKING LOAD OF CONDUCTOR. The calculated breaking load of an aluminium or aluminium alloy conductor, steel reinforced, (in terms of the sum of the strengths of the individual component wires before stranding), is taken as 98 percent of the sum of the strengths of the aluminium or aluminium alloy wires plus 85 percent of the sum of the strengths of the steel wires based on the calculated minimum breaking loads of the component wires.

NOTE: The actual breaking load may vary from the calculated value by 5 percent.

TABLE A1

STRANDING CONSTANTS, AREA, MASS AND RESISTANCE

1	2	3	4	5	6	7	8	9
Number of wires in conductor		Area and mass stranding constants				Resistance stranding constants		
		Aluminium or aluminium alloy		Steel		Aluminium or aluminium alloy	Galvanized steel	Aluminium-clad steel
Aluminium or aluminium alloy	Steel	Area	Mass	Area	Mass			
3	4	2.971	3.029	3.971	4.029	0.3366	0.2518	0.2518
4	3	3.962	4.039	2.981	3.019	0.2524	0.3355	0.3355
6	1	5.910	6.091	1.000*	1.000	0.1692	—	1.000
6	7	5.910	6.091	6.968*	7.032	0.1692	—	0.1435
18	1	17.67	18.34	1.000*	1.000	0.05660	—	1.000
30	7	29.34	30.67	6.968*	7.032	0.03408	—	0.1435
54	7	52.80	55.23	6.968*	7.032	0.01894	—	0.1435
54	19	52.80	55.23	18.85*	19.15	0.01894	—	0.5305

* Applicable only to aluminium-clad steel.

APPENDIX B

CALCULATION OF MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

(This Appendix does not form an integral part of this Standard.)

B1 MODULUS OF ELASTICITY.

B1.1 General. The final modulus of elasticity of a non-homogeneous conductor is dependent on a number of factors including the conductor's previous thermal and tensile history, the method of stranding and the actual conductor configuration. Theoretical values of the modulus can however be calculated from a knowledge of the component material properties and assuming a specific conductor construction. The calculation takes into account the fact that only the centre wire lies parallel to the conductor's axis.

B1.2 Calculation. The calculated values of the final modulus given in Table B1 have been determined using the method of Nigol and Barrett* and the following assumptions:

(a) The mean lay ratio has been used (see Paragraph A2).

(b) No slippage between steel core and aluminium or aluminium alloy wires.

(c) No radial elastic component.

(d) Material moduli in accordance with Clauses 2.3.2.5 and 2.3.3.5.

The following relationships apply*:

$$\tan \theta_i = \frac{2\pi r_i}{L_i D_i}$$

$$E_{ij} = Ew_{ij} \cos^3 \theta_i$$

$$E_f = \frac{1}{A_T} \left\{ E_c A_c + \sum_{j=1}^{N_i} \left[\sum_{i=1}^{n} (m_{ij} A_{ij} E_{ij}) \right] \right\}$$

where

L_i = mean lay ratio of layer i

D_i = external diameter of layer i

r_i = radius of layer i, from centre of conductor to centre of wire in the layer

θ_i = lay angle of wires in layer i

Ew_{ij} = material modulus of wires in layer i of material j

E_{ij} = wire modulus in layer i of material j

m_{ij} = number of wires in layer i of material j

N_i = number of materials in layer i

n = number of layers

E_c = central wire material modulus

E_f = calculated final non-homogeneous conductor modulus

A_{ij} = area of wire in layer i of material j

A_c = area of central wire

A_T = total cross-sectional area of conductor

B2 COEFFICIENT OF LINEAR EXPANSION.

B2.1 General. The coefficient of linear expansion (CLE) of a non-homogeneous conductor may be calculated from a knowledge of the material properties and the areas of each component making up the conductor.

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* The method used to determine the modulus of elasticity was derived from a report prepared for the Canadian Electrical Association under Contract 78-93, March 1982, titled *Development of an Accurate Model of ACSR Conductors for Calculating Sags at High Temperature—Part 3*, by D. Nigol and S. Barrett.

B2.2 Calculation. The values of the coefficient of linear expansion in Table B1 have been determined assuming there is no slippage between steel and aluminium and using the following material properties:

(a) Material moduli is in accordance with Clauses 2.3.2.5 and 2.3.3.5.

(b) Material coefficient of linear expansion is in accordance with Clauses 2.3.2.6 and 2.3.3.6.

The following relationship applies:

$$\alpha_c = \frac{A_1E_1\alpha_1 + A_2E_2\alpha_2}{A_1E_1 + A_2E_2}$$

where

A_1, A_2 = area of material 1, 2

E_1, E_2 = modulus of material 1, 2

α_1, α_2 = CLE of material 1, 2

α_c = CLE of non-homogeneous conductor

TABLE B1

MODULUS OF ELASTICITY AND COEFFICIENT OF LINEAR EXPANSION

Number of wires		Final modulus of electricity, GPa				Calculated coefficient of linear expansion per degree Celsius	
Aluminium or aluminium alloy	Steel	ACSR/GZ and AZ AACSR/GZ and AZ		ACSR/AC AACSR/AC			
		Calculated	Practical	Calculated	Practical	ACSR/GZ and AZ AACSR/GZ and AZ	ACSR/AC AACSR/AC
6	1	83	—	79	—	19.3×10^{-6}	20.1×10^{-6}
6	7	80	—	76	—	19.9×10^{-6}	20.6×10^{-6}
18	1	71	—	69	—	21.4×10^{-6}	21.8×10^{-6}
30	7	88	81-85	82	78-80	18.4×10^{-6}	19.4×10^{-6}
54	7	78	74	75	—	19.9×10^{-6}	20.6×10^{-6}
54	19	77	69-73	74	—	20.0×10^{-6}	20.7×10^{-6}
3	4	136	—	119	—	13.9×10^{-6}	15.3×10^{-6}
4	3	119	—	106	—	15.2×10^{-6}	16.5×10^{-6}

NOTES:

1. Practical values of conductor modulus based on actual conductor test measurements have been provided where available. The calculated values are regarded as being of sufficient accuracy for direct use in conductor sag/tension calculations.
2. Coefficient of linear expansion values quoted may be taken as applying to conductors with a maximum operating temperature of 100°C.
3. Tabulated values given are based on standard diameters and are given for information only.

APPENDIX C

A CONTINUITY OF COATING TEST FOR ALUMINIUM-COATED STEEL

(This Appendix does not form an integral part of this Standard.)

C1 SCOPE. A suitable test which has been applied to aluminium-coated wire in the laboratory is set out in this Appendix.

C2 PREPARATION OF SPECIMENS. Specimens of degreased aluminium-coated steel wire are sealed at the cut ends with wax or any other suitable material.

C3 PROCEDURE. Prepared specimens are immersed in a solution of 1.0 percent potassium ferricyanide and 0.5 percent of 98 percent sulphuric acid, in water, at an ambient temperature of 20 ±3°C.

C4 RESULTS. Pinholes and other discontinuities in the coating are indicated by the formation of dark blue spots.

Any pinholes which do not appear within five minutes may be considered insignificant.

NOTES:

1. This test depends on the formation of ferrous sulphate by the action of the sulphuric acid on the exposed iron, followed by a reaction between the ferrous sulphate and the potassium ferricyanide to form potassium ferric ferrocyanide (prussian blue).
2. Care should be taken to avoid agitation of the solution during the test as the prussian blue formed will mix with the body of the solution and not be localized at the pinholes. This may also happen by diffusion if the test is prolonged.
3. Potassium ferricyanide should not be confused with potassium cyanide, which is extremely toxic. Normal methods of handling chemicals are recommended.
4. It is considered that occasional small pinholes in the coating would not have a serious effect on the suitability of the wire for service.

   Aluminium is normally anodic to iron in the electrolytic cell set up under corrosive conditions and would be expected to corrode preferentially. Also, the large area of aluminium (anode) to iron (cathode) would also be expected to inhibit the corrosion of the iron.

APPENDIX D

DETERMINATION OF MASS OF ALUMINIUM COATING

(This Appendix forms an integral part of the Standard.)

D1 SCOPE. This Appendix sets out the method for determining the mass of aluminium coating on wire.

D2 PREPARATION OF SPECIMENS. The specimens of wire shall be selected in accordance with Clause 4.1.2 or Clause 4.1.3.

The specimens to be stripped may be any length, but preferably over 300 mm. It is not necessary to measure the length. The specimen may be cut into convenient lengths (about 150 mm), for the determination of mass on a chemical balance; the several pieces may be dealt with as one specimen for the determination of mass and the stripping.

The specimens shall be cleaned by washing in petroleum ether or other suitable solvent and dried thoroughly, immediately before the determination of mass.

D3 REAGENTS. The following reagents shall be used:

(a) Sodium hydroxide solution (20 percent). Dissolve 20 parts by mass of sodium hydroxide (NaOH) in 80 parts of water.

(b) Hydrochloric acid (ϱ = 1190 kg/m^3).

D4 PROCEDURE. The procedure shall be as follows:

(a) Before stripping, determine the mass of the specimens. The determination of mass may be carried out on individual specimens, or on a number of specimens together depending on whether a minimum or average value of the mass of coatings is desired.

(b) Heat the sodium hydroxide solution to between 90 °C and 100 °C (Note 1) and immerse each specimen in the hot solution until the strong reaction ceases. With silicon-free coatings, gas may be evolved for a considerable time but the specimens should not be left in the solution for more than a few minutes. Longer immersion inhibits the removal of coating during subsequent dips. Several specimens may be immersed simultaneously provided all surfaces are freely exposed to the solution.

(c) Remove the specimens and wipe with a clean cellulose sponge under running water to remove the loose deposit formed in the hot solution. Blot with a towel to remove most of the water (Note 2) and immerse each specimen singly for not more than 3 s in hydrochloric acid at room temperature. Remove, clean again with a sponge under water, and re-immerse in the hot solution for not more than a few minutes or until action again ceases. Repeat cycle until immersion in hydrochloric acid shows no visible reaction (Note 3). One to three or more cycles may be required, depending on the type of coating.

(d) After the final immersion in the sodium hydroxide and hydrochloric acid solutions, clean as before and dry thoroughly. Determine the mass and diameter of the wire after stripping. The diameter should be measured to the nearest 0.01 mm by taking the average of two measurements made at right angles to each other.

D5 CALCULATION. Calculate the mass of aluminium coating in grams per square metre as follows:

$$\text{Mass of coating} = \frac{m_1 - m_2}{m_2} \times D \times 1960$$

where

m_1 = original mass of specimen, in grams

m_2 = mass of stripped specimen, in grams

D = diameter of stripped specimen, in millimetres.

D6 REPORT. The mass of coating shall be reported to the nearest whole number.

NOTES:

1. The temperature is not critical but the solution should be held several degrees below the boiling point (approximately 105 °C) to prevent excessive foaming during the first immersion. The beaker used for heating the solution and immersing the specimens should be less than half full of solution to avoid the danger of foaming over when the specimens are immersed.
2. Most of the water should be removed to prevent dilution of the hydrochloric acid. (Dilute hydrochloric acid will attack the base metal to a greater extent than concentrated acid.)
3. It is sometimes difficult to determine the point at which all the aluminium layer has been removed when stripping silicon-free coatings. If in doubt, determine the mass of the specimen (after scrubbing and drying) and then put the specimen through one additional stripping cycle. Loss in mass due to the additional cycle will be of the order of 0.75 g/m^2 if all the coating has been removed before the extra cycle.

APPENDIX E

CODE NAMES FOR ALUMINIUM AND ALUMINIUM ALLOY CONDUCTORS, STEEL REINFORCED

(This Appendix does not form an integral part of the Standard.)

Table E1 gives code names for aluminium conductors steel reinforced.

For aluminium alloy conductors steel reinforced, code names are given by the code for the corresponding stranding of aluminium conductor steel reinforced, together with a suffix indicating the alloy type.

e.g. 30/7/3.00 ACSR/GZ: Lemon.
30/7/3.00 AACSR/GZ/1120: Lemon 1120.
30/7/3.00 AACSR/GZ/6201: Lemon 6201.

TABLE E1
CODE NAMES FOR ALUMINIUM CONDUCTORS STEEL-REINFORCED

Stranding and wire diameter, mm		Zinc-coated steel reinforced ACSR/GZ	Aluminium-coated steel reinforced ACSR/AZ	Aluminium-clad steel reinforced ACSR/AC
Aluminium	Steel			
6/2.50	**1/2.50**	**Almond**	**Barley**	**Angling**
6/2.75	1/2.75	Apricot	—	Aquatics
6/3.00	**1/3.00**	**Apple**	**Bean**	**Archery**
6/3.75	**1/3.75**	**Banana**	**Cabbage**	**Baseball**
6/4.75	**7/1.60**	**Cherry**	**Carrot**	**Bowls**
18/3.50	1/3.50	Fig	—	Boxing
30/2.50	**7/2.50**	**Grape**	—	**Cricket**
30/3.00	**7/3.00**	**Lemon**	—	**Darts**
30/3.25	7/3.25	Lychee	—	Dice
30/3.50	7/3.50	Lime	—	Diving
54/3.00	**7/3.00**	**Mango**	—	**Golf**
54/3.25	**7/3.25**	**Orange**	—	**Gymnastics**
54/3.50	**7/3.50**	**Olive**	—	**Hurdles**
54/3.75	**19/2.25**	**Pawpaw**	—	**Lacrosse**
3/1.75	4/1.75	Quince	—	Skating
3/2.50	**4/2.50**	**Raisin**	—	**Soccer**
4/3.00	3/3.00	Sultana	—	Swimming
4/3.75	3/3.75	Walnut	—	Tennis

NOTE: Sizes shown in bold type are preferred sizes for ACSR conductors 18/3.50 – 1/3.50 size is a preferred size for AACSR/1120 only.

APPENDIX F

ITEMS TO BE SPECIFIED BY THE PURCHASER OR SUBJECT TO AGREEMENT BETWEEN THE PURCHASER AND MANUFACTURER

(This Appendix does not form an integral part of the Standard.)

F1 GENERAL. Some of the items listed are additional to the purchasing details normally provided by the purchaser at the time of order and should either be specified by the purchaser or be subject to agreement between the purchaser and manufacturer.

F2 ITEMS TO BE SPECIFIED BY THE PURCHASER.

(a) Whether the conductor is to be greased and if so wholly or partly, and whether the grease must have other special characteristics, (see Clause 2.2.3 and Clause 3.1.3).

(b) Whether a king wire is required, (see Clause 3.1.2).

(c) Requirement for coloured thread identifiers, for alloy 1120, and alloy 6201A, (see Clause 3.2).

(d) Whether special tests are required (see Clause 4.1.1).

(e) Whether optional routine tests (P10) are to be carried out (see Table 4.1).

(f) Whether a continuity of coating test is required for aluminium coated (AZ) wire, and if so, the method to be used, (see Clause 4.4.2.3).

(g) Requirements for test certificates, (see Clause 4.8).

(h) Requirements for any additional information to be marked on the drum flange or the label, see Clause 5.2, and any special method of marking if not in accordance with Note 1 of Clause 5.2.