

SPECIFICATION P-50:88
(UDC 621.315.5)

ALUMINIUM CONDUCTORS, STEEL - REINFORCED



PAKISTAN
WATER AND POWER DEVELOPMENT AUTHORITY
DESIGN DEPARTMENT (T&G)

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AMENDMENT NO. 1 DATED 12th FEBRUARY 90.

1. CLAUSE 2.4

Please add the words "Conductor is held vertically. With left-hand lay, the" at the end of third line of this clause.

2. CLAUSE 3.4

- i) Please add the word "a" in the parenthesis at the end of the heading of this clause.
- ii) Please add the word "a" after the words "coefficient of resistance" in the second line of this clause.

3. CLAUSE 4.2

Please add the words "the value for the coefficient of linear expansion of" after the words "taken as" in the second line of this clause.

4. CLAUSE 5.1

Please add the word "dip" after the word "hot" in fourth line of this clause.

5. CLAUSE 5.1.3, TABLE-I

Please replace the words "Tensile strength" with the words "Tensile stress" in the third line of the heading of this table.

6. CLAUSE 6.1, TABLE-IV

Please replace the figure "45/3.38" with "54/3.38" for Cardinal Conductor in the last row and second column of this table.

7. CLAUSE 6.4.3, TABLE-V

- i) Please replace the heading of this table with the following:

No. of Wires in Conductor	Stranding Constants		Electrical Resistance
	Weight		
Aluminium Steel	Aluminium	Steel	

- ii) Please replace the value "0.091" with "6.091" in the second row and third column of this table.
- iii) Please delete the ninth row of this table which is also given hereunder:

" 30 / 60.67 7.032 0.03408"

8. CLAUSE 8.5

Please add the word "not" after the words "layer shall" in fifth line of this clause.

9. CLAUSE 9.2

Please replace the word "givne" in 10th line with "given".

10. CLAUSE 10.1

Please replace the word "then" in 1st line of this clause with "than".

11. CLAUSE 10.1 (ii)

- i) Please replace the word "Weight" in the 1st line of this sub clause with "Weigh".
- ii) Please replace the word "100 mm" in 5th line of this sub clause with "100 ml".
- iii) Please replace the words "-1950 d.r." in 10th line of page 11 with "-1950 d.r."

12. CLAUSE 10.3.1

Please replace the words "The specimens" in fourth & fifth lines of this clause with "Test specimens".

13. CLAUSE 11

- i) Please replace the formula for resistance at 20°C (R20) as under:

$$R_{20} = RT \left(\frac{1}{1 + a(T-20)} \right)$$

- ii) In the second last line of page 12, please write the word "a" in the blank space which is after the word "and" & on the left side of the sign of equality.

14. CLAUSE 12.2

Please replace the word "given" in 4th line with "giving".

15. CLAUSE 13.2

Please delete the word "k" before the word "regardless" in the 1st line of this clause.

16. CLAUSE 14.1

Please add the sentence "The reels should be suitable for tension stringing and capable to withstand its rigours" after second sentence in the fifth line of this clause.

17. FIG-1, REEL DIMENSIONS

Please delete the 6th row in the table of Figure-1 for Rail Conductor which is also given hereunder:

"Rail NR1850 1850 70 900 1000 70 50 1800 2878"

C O N T E N T S

0. Foreword
1. Scope
2. Definitions
3. Standards for Hard-drawn Aluminium Wire
4. Standards for Steel Wire
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PRINTING HISTORY

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ALUMINIUM CONDUCTORS, STEEL - REINFORCED

- 0 FORL
- 0.1 This standard has been prepared by the Standards Directorate of Design Department of Air Wing, WAPDA. It lays down Specification for Aluminium Conductors Steel-Reinforced (ACSR).
- 0.2 This edition supersedes P-50:79.
- 0.3 This Specification is intended for procurement of material and does not include provisions of contract.
- 0.4 This specification is subject to revision as and when required.

1 **SCOPE**

- 1.1 This specification covers concentric layers stranded conductors, made from round aluminium wire and round zinc coated steel core wires, for use as overhead electrical conductors.

2 **DEFINITIONS**

- 2.1 For the purposes of this specification the following definitions shall apply.

2.2 **Aluminium Conductor, Steel-Reinforced**

Conductor consisting of seven or more aluminium and zinc-coated steel wires built up in concentric layers. The centre wire or wires are of zinc-coated steel and the outer layers of aluminium.

2.3 **Diameter**

Mean of two measurements at right angles taken at the same cross-section.

2.4 **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 "Z" when the wires conform to the direction of the central part of the letter "S" when the conductor is held vertically.

2.5 **Lay Ratio**

Ratio of the axial length of a complete turn of the helix formed by the wires of a stranded conductor, to the external diameter of the conductor.

3 STANDARDS FOR HARD DRAWN ALUMINIUM WIRE

3.1 Resistivity

The resistivity of aluminium wire depends upon its purity and its physical condition. For the purposes of this specification the maximum value permitted is 0.028264 ohm. sq. mm/m at 20°C and this value shall also be used as the standard resistivity for the purpose of calculation.

3.2 Density

At a temperature of 20°C, the density of hard-drawn aluminium wire is to be taken as 2.703 kg/dm³.

3.3 Coefficient of Linear Expansion

The coefficient of linear expansion of hard-drawn aluminium wire is to be taken as 23×10^{-6} per centigrade degree.

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 to be taken as 0.00403 per centigrade degree.

4 STANDARDS FOR ZINC-COATED STEEL WIRE

4.1 Density

At a temperature of 20°C, the density of zinc-coated steel wire is to be taken as 7.80 kg/dm³.

4.2 Coefficient of Linear Expansion

In order to obtain uniformity in calculations, a value of 11.5×10^{-6} per centigrade degree may be taken as zinc-coated steel wires used for the cores of aluminium conductors, steel-reinforced.

5 MATERIAL

5.1 The conductor shall be constructed of hard-drawn aluminium and zinc-coated steel wires which have the mechanical and electrical properties herein. The coating on the zinc-coated steel wires may be applied by the hot process or the electrolytic process.

5.1.1 WAPDA, by specific orders, may require application of a grease containing petroleum and resin on the steel core as well as inner layers of aluminium strands which shall completely fill up the blanks left between the strands. The guaranteed dropping temperature of grease shall not be less than 100°C.

- 5.1.2 The wires shall be smooth and free from imperfections not consistent with good commercial practice.
- 5.1.3 The mechanical properties of hard-drawn aluminium wire shall be in accordance with Table-I given below. For wire of intermediate diameter, the minimum ultimate tensile stress shall be the same as that for the next larger diameter listed in Table-I.

TABLE - I

MECHANICAL PROPERTIES OF HARD-DRAWN ALUMINIUM WIRE

Nominal wire diameter mm	Minimum Ultimate Tensile Strength	
	Before Stranding Kg/sq.mm	After Stranding Kg/sq.mm
1.25	20.4	19.4
1.50	19.7	18.7
1.75	19.2	18.2
2.00	18.8	17.9
2.25	18.4	17.5
2.50	18.0	17.1
2.75	17.6	16.7
3.00	17.2	16.3
3.25	16.9	16.0
3.50	16.7	15.9
3.75	16.5	15.7
4.00	16.3	15.5
4.25	16.3	15.5
4.50	16.2	15.4
4.75	16.2	15.4
5.00	16.2	15.4

5.2 Steel

- 5.2.1 The steel core wires shall be made from open hearth or electrical furnace steel with chemical composition specified in Table-II.

TABLE - II CHEMICAL COMPOSITION OF STEEL WIRE

Carbon, per cent	0.50 to 0.75
Manganese, per cent	0.50 to 1.10
Phosphorus, max, per cent	0.040
Sulfur, max, per cent	0.050
Silicon, per cent	0.10 to 0.30

- 5.2.2 The mechanical properties of the steel core wires shall be in accordance with Table-III. The steel core wire or wires shall be galvanized by hot dip process or electro-

lytic process to achieve the minimum weight of coating specified in Table-III. The zinc used for galvanizing shall be of not less than 99.5 percent purity.

For wire of intermediate diameter, the mechanical properties and zinc coating requirements shall be the same as those for the next larger diameter listed in Table-III.

TABLE-III MECHANICAL PROPERTIES AND ZINC COATING REQUIREMENTS FOR STEEL WIRE

Nominal Wire Diameter mm	Minimum stress at 1% extension kg/mm ²	Minimum tensile stress		Minimum weight of zinc coating g/m ²	Minimum number of 1-minute dips
		Before strand-	After strand-		
		kg/mm ²	kg/mm ²		
1.25	119.5	133.6	126.9	183	2
1.50	119.5	133.6	126.9	183	2
1.75	119.5	133.6	126.9	198	2
2.25	119.5	133.6	126.9	214	2.5
2.75	116.0	133.6	126.9	229	3
3.00	116.0	133.6	126.9	244	3.5
3.50	112.5	133.6	126.9	244	3.5
4.25	112.5	133.6	126.9	259	4
4.75	112.5	133.6	126.9	275	4

6 DIMENSIONS AND CHARACTERISTICS

6.1 Standard Sizes

The dimensions and characteristics of the conductors standardized for use by WAPDA are given in Table-IV.

TABLE-IV DIMENSIONS AND CHARACTERISTICS OF ACSP

Code Word	Aluminium Conductor No/mm	Steel Core No/mm	Diameter Composite Conductor mm	Steel Core mm	Cross area of aluminium mm ²	Area of composite conductor mm ²	Rated ultimate strength kg	D.C. resistance at 20°C ohm/km	Weight kg/km
Gopher	6/2.36	1/2.36	7.08	2.36	26.25	30.62	980	1.093	106
Rabbit	6/3.35	1/3.35	10.05	3.35	52.88	61.69	1875	0.543	214
Dog	6/4.72	7/1.57	14.15	4.71	104.98	118.53	3225	0.273	394
Lynx	30/2.79	7/2.79	19.53	8.37	183.41	226.20	8192	0.158	842
Cuckoo	24/4.62	7/3.08	27.72	9.24	402.33	454.48	12385	0.072	1519
Rail	45/3.70	7/2.47	29.61	7.41	483.84	517.38	11874	0.060	1599
Cardinal	45/3.38	7/3.38	30.42	10.14	484.5	547.3	15262	0.060	1832

6.2 Tolerance on Nominal Diameter of Wires

6.2.1 Aluminium Wires

The aluminium wires shall not depart from the nominal

diameter by more than the following amounts.

Nominal Diameter	Tolerance
2.50 mm and greater	$\pm 1\%$
Less than 2.50 mm	± 0.025 mm

6.3 Zinc Coated Steel Wires

The zinc coated steel wires shall not depart from the nominal diameter by more than the following amounts.

Nominal Diameter	Tolerance
2.00 mm and greater	$\pm 2\%$
Less than 2.00 mm	$\pm 0.04\%$

6.4 Calculation of Conductor Properties

6.4.1 The properties of the conductors have been calculated in accordance with Clauses 6.4.2 to 6.4.4 below.

6.4.2 Increase in length due to stranding. When straightened 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 mean lay ratio of that layer.

6.4.3 Resistance and Weight 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 aluminum 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, as given in Table-V.

TABLE-V STRANDING CONSTANTS

No. of Wires in Conductor		Weight		Stranding Constants
Aluminium	Steel	Aluminium	Steel	Electrical Resistance
6	1	6.091	1.000	0.1692
6	7	6.091	7.032	0.1692
12	7	12.26	7.032	0.08514
18	1	18.34	1.000	0.05660
24	7	24.50	7.032	0.04253
26	7	26.56	7.032	0.03928
28	7	28.61	7.032	0.03649
30	7	30.67	7.032	0.03408
30	7	60.67	7.032	0.03408
30	19	30.67	19.15	0.03408
32	19	32.66	19.15	0.3189
45	7	45.98	7.032	0.02271
54	7	55.23	7.032	0.01894
54	19	55.23	19.15	0.01894

The weight 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 mean lay ratio of the layer. The total weight of any length of a conductor is therefore obtained by multiplying the weight of an equal length of straight wire by the appropriate constant given in Table-V above. The weight of the steel core and aluminium wires are calculated separately and added together.

- 6.4.4 Strength of Conductor. The strength of a conductor, in terms of strength of the individual component wires, may be taken to be the sum of the strengths of the aluminium wires calculated from the value of the aluminium ultimate tensile given in column 2 of Table-I plus the sum of the strengths of the steel wires calculated from the value of the minimum stress at 1% extension given in column 2 of Table-III.

For testing the ultimate tensile strength of a complete conductor, suitable fittings shall be applied to the ends of a sample of conductor which shall be not less than 5 m long and the assembly shall then be pulled in a suitable tensile machine. When so tested the conductor shall withstand at least 95% of its strength, calculated as indicated above.

7 JOINTS IN WIRES

7.1 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 base rod or wire before final drawing, but no such joints shall be less than 15 m apart in the complete stranded conductor. Such joints shall be made by resistance or cold pressure butt welding. They are not required to fulfill the mechanical requirements for unjointed wires. Joints made by resistance butt welding shall, subsequent to welding, be annealed over a distance of at least 200 mm on each side of the joint.

7.2 Zinc-coated Steel Wires

No joints of any kind shall be permitted in the zinc-coated steel wires other than those made by resistance butt welding in the base rod before drawing.

8 STRANDING

- 8.1 The wires used in the construction of an aluminium conductor, steel-reinforced shall, before stranding, satisfy all the relevant requirements of this specification.

8.2 The lay ratio of the different layers shall be within the limits given in Table-VI.

TABLE-VI LAY RATIOS

Number of Wires	Aluminium wire diameter to steel wire diameter	Ratio	Lay Ratios for Steel Core				Lay Ratios for Aluminium Wires					
			6-Wire Layer	12-Wires Layer	Out side layer	Layer immediately beneath outside layer	Innermost Layer of Conductors with 3-aluminium wire layer	Min	Max	Min	Max	
6	1	1.000	-	-	-	-	10	14	-	-	-	-
6	7	3.000	13	20	-	-	10	14	-	-	-	-
12	7	1.000	13	28	-	-	10	14	-	-	-	-
18	1	1.000	-	-	-	-	10	14	10	16	-	-
24	7	1.500	13	28	-	-	10	14	10	16	-	-
25	7	1.386	13	28	-	-	10	14	10	16	-	-
28	7	1.125	13	28	-	-	10	14	10	16	-	-
30	7	1.000	13	28	-	-	10	14	10	16	-	-
30	19	1.666	13	28	12	24	10	14	10	16	-	-
32	19	1.500	13	28	12	24	10	14	10	16	-	-
45	7	1.500	13	28	-	-	10	14	10	16	10	17
54	7	1.000	13	28	-	-	10	14	10	16	10	17
54	19	1.666	13	28	12	24	10	14	10	16	10	17

8.3 The ratio of the nominal diameter of the aluminium wires to the nominal diameter of the zinc-coated steel wires in any particular construction of the aluminium conductor, steel-reinforced, shall conform to the appropriate value given in column 3 of Table-VI.

8.4 In all construction, the successive layers shall have opposite directions of lay, the outermost layer being right-handed. The wires in each layer shall be evenly and closed stranded.

8.5 In a 12-wire steel core, the lay ratio of the 12-wire layer shall be not greater than the lay ratio of the 6-wire layer. Similarly in a conductor having multiple layers of aluminium wires, the lay ratio of any aluminium layer shall be greater than the lay ratio of the aluminium layer immediately beneath it.

9 MECHANICAL TESTS

9.1 Stress at 1% Extension

This test shall be made on zinc-coated steel wires only.

One specimen cut from each of the samples shall be gripped in the jaws of a tensile testing machine. A load corresponding to the appropriate tensile stress given in column 2 of table-VII and an extensometer shall be applied on a 50 mm, 200 mm or 250 mm gauge length and adjusted to the appropriate initial setting given in column 3 (or 4 or 5) of table-VII.

For wire of intermediate diameter, the initial stress and the initial extensometer setting shall be the same as that for the next larger diameter listed in Table-VII.

The load shall then be increased uniformly until the extensometer indicates an extension of 0.5 mm in 50mm, 2.00 mm in 200 mm or 2.50 mm in 250 mm. At this point, the load shall be read, from which the value of the stress at 1% extension shall be calculated. The value obtained for the specimen shall be not less than the appropriate value given in column 2 of table-III.

TABLE-VII INITIAL STRESS AND EXTENSOMETER SETTING FOR DETERMINATION OF STRESS AT 1% EXTENSION

Nominal Diameter mm	Initial Stress kg./mm ²	Initial Setting of Extensometer		
		mm in 50 mm	mm in 200mm	mm in 250 mm
1.25	10	0.025	0.10	0.125
2.25	10	0.025	0.10	0.125
3.00	20	0.050	0.20	0.250
4.75	30	0.075	0.30	0.375

9.2 Tensile Test

This test shall be made on both aluminium and steel wires prior to and after stranding. The breaking load of the specimen cut from the sample 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.

When tested before stranding the ultimate tensile strength of the specimen shall be not less than the appropriate value given in column 2 of Table-I or column 3 of Table-III.

When tested after stranding the ultimate tensile strength, of the specimen shall not be less than the appropriate value given in column 3 of Table-I or column 4 of Table-III.

9.3 Ductility Test

This test shall be made on zinc-coated steel wires only.

- (a) One specimen cut from each of the sample shall be gripped at its ends in two vices, one of which shall be free to move longitudinally during the test. A small tensile load, not exceeding 2% of the breaking strength of the wire, shall be applied to the sample during testing. The specimen shall be twisted by causing one of the vices to revolve until fracture occurs and the number of twists shall be indicated by a counter or other suitable device. The rate of twisting shall not exceed 60 rev/min.

When tested before stranding, the number of complete twists before fracture occurs shall be equivalent to not less than 18 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles to the axis of the wire.

When tested after stranding, the number of complete twists before fracture occurs shall be equivalent to not less than 16 on a length equal to 100 times the diameter of the wire. The fracture shall show a smooth surface at right angles to the axis of the wire.

- (b) As an alternative to the torsion test, an elongation test may be made on zinc-coated steel wires. The elongation of one specimen cut from each of the sample shall be determined. The specimen shall be straightened by hand and an original gauge length of 200 mm shall be marked on the wire. A tensile load shall be applied as described in clause 9.2 and the elongation shall be measured after the fractured ends have been fitted together. If the fracture occurs outside the gauge marks, or within 25 mm of either mark, and the required elongation is not obtained, the test shall be disregarded and another test made. When tested before stranding, the elongation shall be not less than 4%. When tested after stranding, the elongation shall be not less than 3.5%.

NOTE: The choice between a torsion test and an elongation test is to be at the discretion of the manufacturer and the choice of one test or the other in no way prejudices the quality of the steel used.

9.4 Wrapping Test

This test shall be made on both aluminium and zinc-coated steel wires.

(i) For Aluminium Wires

One specimen cut from each of the sample of aluminium wire shall be wrapped round a mandrel of diameter equal to the wire diameter to form a close helix of eight turns. Six turns shall then be unwrapped and again closely wrapped. The wire shall not break or show any cracks.

(ii) For Zinc-coated Steel Wires

One specimen cut from each of the sample of zinc-coated steel wire shall be wrapped round a mandrel of diameter equal to the wire diameter to form a close helix of eight turns. The wire shall not break.

10 GALVANIZING TESTS

10.1 Determination of Weight of Zinc-coating

The specimen of galvanized wire shall be not less than 300 mm long and the weight of the specimen in grams shall be not less than its diameter in millimeters multiplied by 4.

The specimen shall be cleaned by dipping into a suitable solvent, such as benzene, and wiped dry with a clean, soft cloth.

Test Methods

Reagents

(i) Antimony Chloride Solution

Dissolve 20 grams of antimony trioxide or 32 grams of antimony chloride in 1000 ml of hydrochloric acid.

(ii) Hydrochloric Acid (Spec: gravity 1.19)

Weight the specimen to the nearest .01 g. The specimen shall then be stripped of the zinc-coating by complete immersion in any convenient volume of solution made by adding 5 ml of the antimony chloride solution to each 100 ml of hydrochloric acid. The same solution may be repeatedly used without further addition of antimony chloride solution, until the time for stripping becomes inconveniently long. The temperature of stripping solution shall at no time exceed 38°C. As soon as the violent chemical

action on the wire has ceased, the wire shall be removed from the acid, washed thoroughly in running water and wiped dry. The diameter of the wire shall then be determined to the nearest 0.025 mm by taking the average of two measurements at right angles to each other. The specimen shall then be weighed to the nearest 0.01 g.

Calculations

Weight of coating in grams per square metre of stripped wire surface - 1950 d.r.

Where d = diameter in millimetres of stripped wire

$$r = \frac{\text{original weight} - \text{stripped weight}}{\text{stripped weight}}$$

The weight shall be not less than the appropriate value given in column 5 of Table-III.

10.2 Test of Adherence of Zinc-coating

Zinc coated wire shall be capable of being wrapped at a rate not exceeding 15 rev/min in a close helix of at least eight turns round a cylindrical mandrel having a diameter of four times the diameter of the wire for wires of diameter upto and including 3.5 mm and five times the diameter of the wire for wires greater than 3.5 mm. The zinc coating shall remain firmly adherent to the steel and shall not crack or flake to such an extent that any zinc can be removed by rubbing with bare fingers.

10.3 Test for Uniformity of Zinc-Coating

Test Solution

The copper sulphate solution shall be made by dissolving approximately 30 parts by weight of commercial copper sulphate crystals in 100 parts by weight of distilled water. Heat may be used to complete the solution shall be allowed to cool. The solution shall then be shaken with an excess of powdered cupric hydroxide. The presence of an excess of cupric hydroxide will be shown by the sediment of this reagent at the bottom of the vessel. The neutralized solution shall be allowed to stand for 24 hours and then filtered or decanted.

The test solution shall have a specific gravity of 1.186 at 18°C. To adjust a solution of improper specific gravity, add distilled water when the specific gravity is high and add a copper sulphate solution of a higher specific gravity when the test solution is low in specific gravity. Wire specimens shall be tested in a glass container at least 50 mm inside diameter for 2.75 mm dia. wire and smaller, and at least 75 mm inside diameter for wire larger in diameter than 2.75 mm dia. The con-

Container shall be filled with fresh test solution to a depth of at least 100 mm. This quantity of solution shall be used for the simultaneous testing of one to seven test specimens. The solution shall be discarded after completion of the test and fresh solution used for any additional tests.

10.3.1 The Sample

The test specimen shall be cleaned with a volatile organic solvent such as carbon tetrachloride or benzene, then rinsed with alcohol and finally, thoroughly washed with clean water and wiped dry with clean cloth. The specimens shall be brought to a temperature of 15°C to 21°C prior to beginning of the test.

10.3.2 Test Method

The test specimen shall be immersed in the copper sulphate solution, which shall be maintained at a temperature of 18±2°C. The specimens shall remain in a fixed position in the solution for exactly 1 minute. If a 1/2 minute dip is specified, it shall be given to the specimens after completion of all of the 1 min. dips. There shall be no agitation of the solution during the immersion period and the specimen shall not be allowed to touch each other or the sides of the container. After such dip, the specimen shall be washed and wiped dry with a clean cloth. The rinse water may be ordinary clean up water and shall have a temperature of from 15 to 21°C. In conducting a series of tests, the rinse water shall be changed often enough to ensure that it is reasonably free from copper sulphate. Before returning the specimens to the test solution they shall be well drained of excess rinse water and wiped dry with a clean cloth.

Successive dips of 1 min. each shall be continued with washing and wiping of the test specimens after each dip, until the specimens have withstood the required number of dips specified in the column 6 of Table-III or until the end point has been reached.

11 RESISTIVITY TEST

This test shall be made on aluminium wires only. The electrical resistance of specimen shall be measured at temperature which shall be not less than 10°C nor more than 30°C. The measured resistance shall be corrected to value at 20°C by means of the formula.

$$R_{20} = R_T \left(\frac{1}{1 + \alpha_r (T-20)} \right)$$

Where T = Temperature of measurement in °C

R_T = Resistance at T°C

R_{20} = Resistance at 20°C

and α_r = Constant temperature coefficient of resistance (=0.00403)

The resistivity at 20°C shall then be calculated from the resistance at 20°C.

The resistance at 20°C shall not exceed 0.028264 ohm.
mm²/m.

12 TESTS BY MANUFACTURER

12.1 Samples for tests specified in clauses 9, 10 and 11 shall be taken by the manufacturer, before stranding, from not less than 10% of the individual lengths of:

- i) Aluminium wires
- ii) Zinc-coated steel wires

which will be included in anyone consignment of stranded conductor. For the tests specified in clauses 9, 10 & 11 one sample sufficient to provide one test specimen for each of the appropriate tests, shall be taken from each of the selected lengths of wires.

12.2 Visual inspection and verification of dimensions shall be carried out as routine tests on wires and complete conductor. The manufacturer shall furnish certificate given the results of the tests made on samples taken in accordance with sub-clause 12.1.

13 ACCEPTANCE AND REJECTION

13.1 The manufacturer shall divide each consignment into lots for inspection. These lots shall be so selected that material in a lot is of reasonably uniform quality and as far as possible, is manufactured at the same time and under the same conditions. The manufacturer shall keep sufficient production records to ensure that this can be done regularly. A lot may contain any number of lengths upto a maximum of 150.

13.2 From each lot, regardless of its size, samples of wires shall be taken at random from lengths of stranded conductor selected from approximately 10% of the lengths included in anyone consignment. For the tests specified in clauses 9, 10 & 11 one sample sufficient to provide one specimen for each of appropriate tests shall be taken from each strand of the conductor in each of the selected lengths.

13.3 The lot shall be accepted if for each test, the sample complies with the requirements of clauses 13.4 and 13.5.

13.4 If in any test, at most one specimen fails the sample shall be considered acceptable for that test.

13.5 If two specimens fail in any test, a further sample in accordance with clause 13.2, shall be taken from the lot, and the particular test repeated. If there are

no further failures the sample shall be considered acceptable for the test.

- 13.6 If in any test three or more specimens fail, the entire lot shall be rejected.
- 13.7 The manufacturer shall afford to the inspector all necessary test facilities and assistance for carrying out the tests. The facilities shall be provided free of charge.

14 PACKING AND MARKING

14.1 ACSR stranded conductor shall be supplied on standard wooden reels as per fig 1. The reels shall be made from high quality wood and shall be of sound construction able to withstand the usual rigours of transportation and field construction. The complete periphery of the reels apart from being protected by heavy wooden lagging nailed at each end of the reel flanges as per fig 1, shall also be bound by two steel straps. The wooden reels shall be given two brush coats of 5 percent pentachlorophenol solution in oil before winding of conductor. The conductor shall be wound tightly.

14.2 The conductor shall be supplied in lengths specified in table of fig 1. Each reel shall contain either one or two lengths only as specified. A tolerance of plus or minus 5 percent is permitted on the conductor length. Additionally it shall be permissible to supply not more than 5 percent of the lengths on any one order in random lengths, none of which shall be shorter than one third of the nominal lengths.

14.3 The manufacturer shall provide the following markings on the reels in legible and indelible letters.

- 1) Manufacturer's name and designation
- 2) Conductor designation
- 3) Address of the consignee and purchase order number
- 4) Serial number of the reel

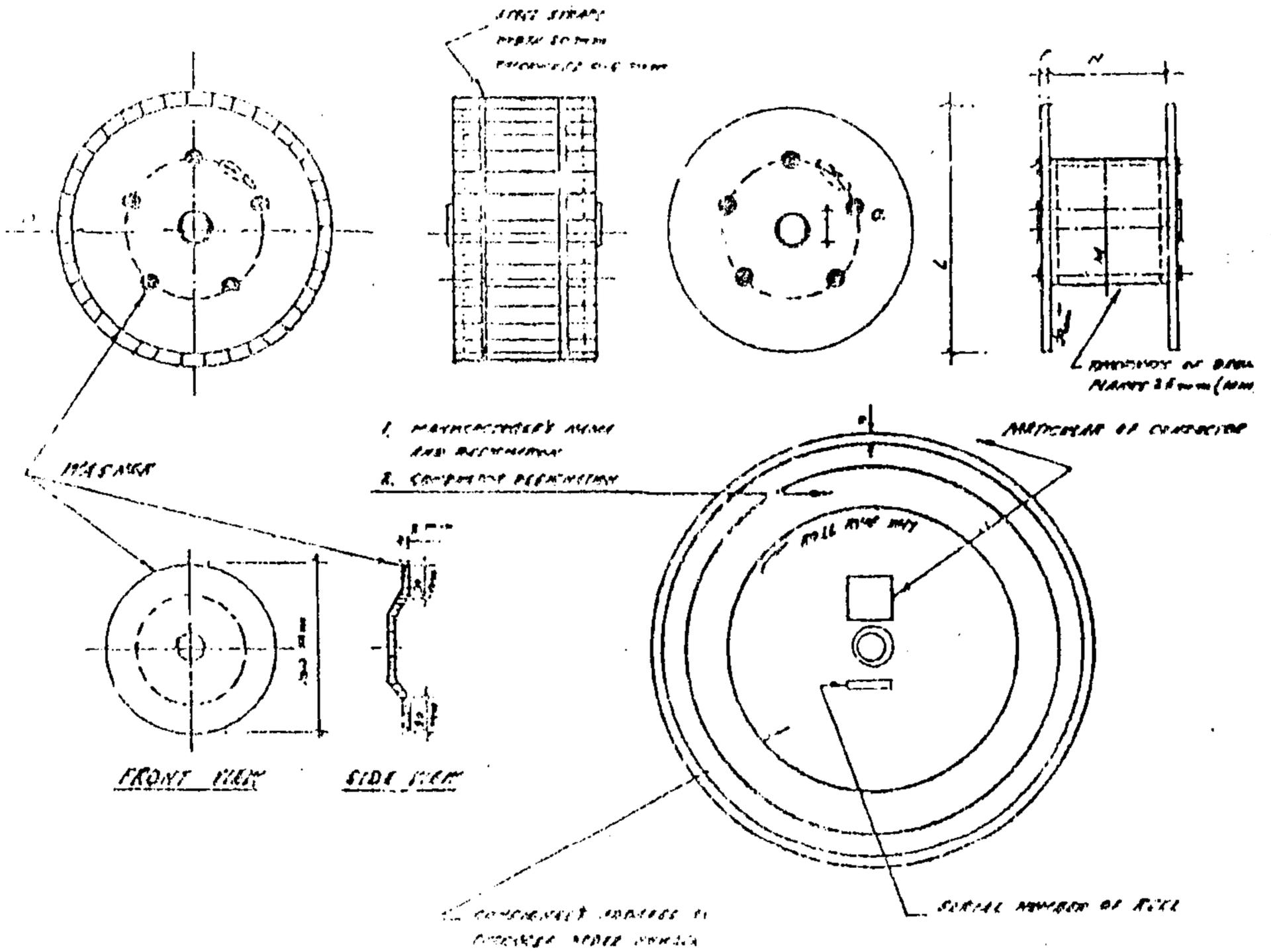
14.4 The manufacturer shall stamp the following information on metallic plates which shall be securely nailed to the reel.

- 1) Size and designation of ACSR stranded conductor.
- 2) Net weight, tare weight and gross weight, in kg.
- 3) Total length of the conductor on the reel, in metres.
- 4) Serial number of the reel

14.5 Both sides of the reel shall have an arrow mark indicating the direction of rolling.

14.6 All markings shall appear on both sides of the reel in the positions indicated in figure 1.

Encls: Fig: 1.



Conductor	Reel Designation	Flange Dia T, m.m	Flange Thickness P, m.m	Outer Dia H, m.m	Inside Width II, m.m	Anchor Hole Ø Q, m.m	Tagging Thickness O, m.m	Nominal Length Meters	Nominal Weight of Conductor Kg.
Gopher	NR910	910	40	450	560	70	50	2x1700	360
Rabbit	NR1070	1070	60	530	700	70	50	2x1600	685
Ixoi	NR1070	1070	60	530	700	70	50	1600	630
Lynx	NR1680	1680	75	970	800	70	50	2300	1937
Cuckoo	NR1850	1850	70	900	1000	70	50	2070	3144
Rail	NR1850	1850	70	900	1000	70	50	1800	2878
Cardinal	NR1850	1850	70	900	1000	70	50	1720	3151
Rail	NR2200	2200	95	1066	1150	125	50	3200	5117

FIG. 1 REEL DIMENSIONS