GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION
FOR
ANNEALED STRANDED COPPER CONDUCTOR
FOR
JUMPER WIRE FOR ELECRIC TRACTION

SPECIFICATION NO. TI/SPC/OHE/JMP/0941

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Copy number

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Date……..

Issued to…….
…….

SPECIFICATION FOR ANNEALED COPPER CONDUCTORS FOR JUMPER WIRES

1 SCOPE

This specification covers the requirements and method of tests for bare stranded annealed copper conductors of concentric and/or rope lay (having concentric stranded members) for nominal system voltage of 25 kV ac at 50 Hz.

The annealed copper conductor is used as jumper wires, not under tension to provide electric continuity and to carry current from one conductor to other or equipment of 25 kV AC OHE.

This specification supersedes the earlier specification no. ETI/OHE/3(1/83). Specification no. ETI/OHE/3(2/94) of this specification is updated to TI/SPC/OHE/JMP/0941 in-line with TI document no. TI-WI-7.5.1-1 ver 1.0.

The "Make in India" Policy of Government of India shall be applicable.

2 GOVERNING SPECIFICATIONS

2.1 The annealed copper conductor for jumper wire shall unless otherwise specified, confirm to the following standards/specification(latest version) which shall be applied in the manner altered, amended or supplemented by this specification

Clause No.	Standard	Title
2.1.1	IS : 191-2007 or latest	Specification for Copper
2.1.2	IS: 1778-1980or latest	Reels and drums for bare conductors
2.1.3	IS: 1885(Pt 32)-2019or latest	Electro-techical vocabulary : Cables, conductors and accessories for electricity supply.
2.1.4	ASTM : B8 or latest	Specification for stranded concentric lay copper conductor.
2.1.5	ASTM: B173-17 or latest	Specification for rope lay stranded copper conductors having concentric stranded members for electric conductors

2.2 In case of any conflict or disparity between the contents of the above specifications and this specification, the latter shall prevail.

2.3 Any deviation from this specification proposed by the manufacturer to improve upon the performance, utility and efficiency of the conductor shall be

considered only on its merits provided full particulars with justification and financial implication are furnished by the manufacturer.

3 ENVIRONMENTAL CONDITIONS

The conductor shall be suitable for outdoor use in moist tropical climate and in areas subject to heavy rainfall, polluted due to industry and marine atmosphere and severe lightning. The limiting weather conditions which the conductor has to withstand in service are indicated below :

TABLE – 1
ENVIRONMENTAL CONDITIONS

SN	Environmental Condition	Limits
i.	Maximum ambient air Temperature.	50^0 C
ii.	Average ambient air Temperature over a period of 24 hours	35^0 C
iii.	Maximum relative humidity	100%
iv.	Annual rainfall	Dry Arid regions and also heavy monsoon affected regions with rainfall ranging from 1750mm to 6250mm.
v.	Maximum number of thunder storm days per annum.	85
vi.	Maximum number of dust storm days per annum.	35
vii.	Number of rainy days per annum	120
viii.	Basic wind pressure	216kgf/m^2
ix.	Altitude	2500 m above mean sea level.

4 TERMINOLOGY

4.0 For the purpose of this specification, the following definition in addition to those given in IS:1885(Part 32):2019 or latest shall apply.

4.1 Stranded Conductor :

Conductor consists of three or more copper wires of the same nominal diameter twisted together in concentric layers. When the conductor consists of more than one layer, successive layers shall be twisted in opposite directions.

4.2 Diameter :

The diameter of wires as well as the conductor shall be measured at right angles at the same cross section at three places. The average diameter of the

wire shall be within the limits prescribed in Clause 5.5 and the average diameter of the stranded conductor shall be not less than the appropriate overall diameters prescribed in Clause 6.1. The tolerance on diameter of the stranded conductor is +1 percent & -0 percent on nominal overall diameter

4.3 Direction of Lay :

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

4.4 Lay Ratio:

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.

5 REQUIREMENT OF WIRES

5.1 Material :

The conductor shall consist of drawn and annealed round bare copper wire for electrical purpose. The wire shall be drawn out of Continuous Cast Copper rods. Copper used to make Continuous cast copper rods should be Electrolytic grade Copper cathodes conforming to the requirement of LME Grade `A' copper as listed in the London Metal Exchange.

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5.2 Volume Resistivity:

The volume resistivity of stranded annealed copper at 20° C shall be not more than 0.017241 ohm mm/m which corresponds to 100 percent conductivity of International Annealed Copper Standard. The volume resistivity is calculated as follows:

$R = (p*l)/A$

Where

R= Resistance in ohm
l = length in meters
A=Area in mm^2
p=0.017241

5.3 Elongation:

The percentage elongation of individual wire when tested over a guage length of 250 mm shall be not less than 25 for the wires before stranding and not less than 20 after stranding.

5.4 Freedom from defects :

The wire shall be clean, smooth and free from harmful defects such as scratches, surface cracking, peelings, abrasion, spills and spurna.

5.5 The standard size of the wire for those conductors shall be the following with the tolerance of ±1 percent on the nominal diameter.

Nominal dia (mm)	Minimum dia (mm)	Maximum dia (mm)
1.016	1.006	1.026
1.25	1.237	1.263
1.80	1.782	1.818
0.95	0.941	0.960

5.6 Joints in the wires except during stranding

The wire shall be drawn in continuous lengths, without joints except those made in the soft rod or wire before final drawing.

5.7 Joints in the stranded conductors

5.7.1. In the case of stranded conductor containing more than 7 wires, a joint in any wire shall be permitted provided that distance between two joints(other than those in wires before stranding permitted under Clause 5.6) in the stranded conductors shall not be less than 15m. Joints shall be hard soldered or butt welded.

5.7.2. Not more than two joints during stranding in 1 km length of conductor shall be permitted.

5.8 Resistance of the wires shall be as under :

	Diameter	Resistance at 20^0 C ohms/km
Minimum	1.006	21.690
Nominal	1.016	21.1265
Maximum	1.026	20.853
Minimum	1.23	14.346
Nominal	1.25	14.049
Maximum	1.263	13.761
Minimum	1.782	6.912
Nominal	1.80	6.775
Maximum	1.818	6.641

Minimum	0.941	24.80
Nominal	0.950	24.33
Maximum	0.960	23.83

6 SIZE OF CONDUCTOR AND CONSTRUCTION

6.1. The nominal area of cross section, numbers and diameters of wires, type of construction, overall diameter, weight of the conductors and resistance/km shall be as under. The tolerance on diameter & weight of the stranded conductor is +1 percent & -0 percent.

S.No.	Nominal area of conductor (mm^2)	No. of strands/ wire dia. (mm)	Construction	Nominal overall dia (mm)	Weight (kg/km)	Resistance at 20^0C (ohm/km)	
						Std.	Max.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.	50	19/1.80	Concentric lay	9.00	438.00	0.3633	0.3705
2.	105	19/7/1.016	Rope lay	15.24	993.60	0.1657	0.1689
3.	160	19/7/1.25	Rope lay	18.75	1504.0	0.1090	0.1117
4.	304	61/7/0.95	Rope lay	25.7	2840	0.0595	0.0607

6.2. Condition of the conductor

The conductor shall be supplied plain, without tinning or any other coating in the length specified by the purchaser.

6.3. Lay

The direction of lay of the outer layer shall be right handed. Successive layers shall have opposite direction of lay.

6.4. Concentric lay-19/1.80 mm conductor

The lay length shall be neither less than 10 times nor more than 16 times the diameter of the conductor.

6.5. Rope Lay-19/7/1.016 mm, 19/7/1.25 mm conductor and 61/7/0.95 mm

The lay length of the outer layer shall be neither less than 8 times nor more than 16 times of the outside diameter of the conductor. The lay length of the other layers shall be at the option of the manufacturer unless specifically agreed upon.

6..5.1. The lay length of the individual wires comprising the stranded conductor shall be neither less than 8 times nor more than 16 times of the outside diameter.

7 TOLERANCE ON LENGTH:

7.1. The conductor shall be delivered in lengths as specified by the purchaser. The tolerance on length shall be :

a) For lengths under 750 m = ± 10 m.

b) For lengths of 750 m and above = ± 20 m or ± 1 percent whichever is less subject to a minimum of ± 10 m

8.0. TESTS

8.1 Type Test :

8.1.1 Once a purchase order is placed for supply of annealed stranded copper conductor(s) for jumper wire for electric traction, the internal test results shall be furnished by the successful manufacturer to the Purchaser/Director General (TI)/RDSO as the case may be within the period stipulated for prototype approval in the order.

8.1.2 Any changes required to be done in the prototype as required by the Purchaser/Director General (TI)/RDSO shall be carried out expeditiously by the successful manufacturer.

8.1.3 Prior to giving a call to the Purchaser/Director General (Traction Installation)/ RDSO for inspection and testing of the prototype, the successful manufacturer shall submit a detailed test schedule consisting of schematic circuit diagrams/layout for each of the tests and the number of days required to complete all the tests at one stretch. Once the schedule is approved, the test shall invariably be done accordingly. However during the process of type testing or even later, the purchaser reserves the right to conduct any additional test(s) besides those specified herein, on conductor so as to test conductor to his satisfaction or for gaining additional information and knowledge. In case any dispute or disagreement arises between the manufacturer and representative of the Director General (TI)/RDSO during the process of testing as regards the procedure for type tests and/or the interpretation and acceptability of the results of type test, it shall be brought to the notice of the purchaser/Director General (TI)/RDSO, as the case may be, whose decision shall be final and binding. Only after the prototype is completed and ready in each and every respect, shall the successful manufacturer give the actual call for the inspection and testing with at least 15 days notice for the purpose.

8.1.4 The following type tests shall be carried out on the conductor/wire at the works of the successful manufacturer in the presence of the representative of the purchaser/DG(TI)/RDSO in accordance with the relevant procedures laid down in this specification.

i. Visual examination (Clause 9.1)
ii. Measurement of diameter of individual wire and stranded conductor(Clause 9.2)
iii. Measurement of lay length (Clause 9.3)
iv. Measurement of weight of ~~wires and~~ conductors (Clause 9.4)
v. Measurement of electrical resistance of stranded conductor (Clause 9.5)
vi. Elongation test on wires (Clause 9.6)
vii. Chemical Analysis (Clause 9.7)

8.1.5 All the tests specified, unless otherwise mentioned elsewhere, in the specification shall be carried out at the manufacturer works. The manufacturer shall arrange all the necessary machinery, apparatus, labour and assistance required for conducting the tests without any extra cost. The tests for which the facilities are not available at the works of manufacturer, may be carried out at any other reputed or government laboratory with prior approval of the purchaser and the cost of such tests shall be borne by the manufacturer.

8.1.6 In the event of the tests not being carried through to completion at one stretch for any reasons attributable to the manufacturer and it is required for the representative of the Purchaser/Director General (TI)/RDSO to go again or more number of times to the works of the manufacturer or other place(s) for continuing and/or completing the tests on the prototype(s) of the conductor/wires, the manufacturer shall reimburse to the Director General (TI)/RDSO the cost for the representative's visits to works or other place(s) for the tests more than once. The costs as claimed by the Purchaser/Director General (Traction Installation), Research Designs & Standards Organisation, Lucknow shall be paid through a demand draft as advised to the manufacturer.

8.1.7 Selection of samples of conductor for type tests

8.1.7.1 In the case of 50 mm^2(19/1.80mm) stranded conductor of concentric lay, three wires before stranding and three wires after stranding shall be take at random for each type test.

8.1.7.2 In case of 105 mm^2 (19/7/1.016 mm), 160 mm^2 (19/7/1.25 mm) and 304 mm^2(61/7/0.95 mm) stranded conductor of rope lay construction, three wires before stranding and nine wires(selected in such way that wire from each layer and core are taken for test)~~(3 wires from each layer and 3 wires from core)~~ after stranding shall be take at random for each type test.

8.1.7.3 For stranded conductors three samples for each size shall be taken at random for each type test.

8.1.8 <u>ACCEPTANCE CRITERIA FOR PROTOTYPE & BULK MANUFACTURE:</u>

8.1.8.1 The samples offered for type tests in accordance with Clause 8.1.4 shall pass all the type tests stipulated in Clause 8.1.4 hereof.

8.1.8.2 Only after clear written approval of the results of the tests on the prototype is communicated by the Purchaser/Director General (TI)/RDSO to the manufacturer, manufacturer shall take up bulk manufacture of the conductor which shall be strictly with the same material and process as adopted for the prototype. In no circumstances shall material other than those adopted during the manufacture of prototype be used for bulk manufacture with the plea that they had been obtained prior to the approval of the prototype.

8.1.8.3 If the prototype of an conductor confirming to this specification has already been approved in connection with previous supplies to Indian Railways, fresh testing of prototype of the conductor may be waived at the discretion of the purchaser, provided that no changes whatsoever in the material or process of manufacture have been made. However, the purchaser reserves the right to test any conductor if he deems it necessary to do so in the light of experience gainer from previous supplies.

8.1.8.4 Notwithstanding approval having been accorded to manufacture the bulk of the conductors on the basis of the results of the type tests, the Purchaser reserves the right to conduct any type or number of tests, including destructive tests at any time during the process of bulk manufacture without prior advice to the manufacturer. All facilities shall be made available to the purchaser to conduct such tests without any charge.

8.2 ACCEPTANCE TESTS:

8.2.1 All the test mentioned in clause 8.1.4 shall constitute the acceptance test.

8.2.2 Selection of samples of conductors for acceptance tests :

Sample of wires and conductors for acceptance tests shall be cut from each drum. After visual examination, the diameter, lay length, weight and electrical resistance shall be measured first. Three wires from 50 mm^2 (one from each layer and core) and nine wires(selected in such way that wire from each layer and core are taken for test)~~((3 wires from each layer and 3 wires from core)~~ for 105 mm^2,160 $mm^2$and 304 mm^2 jumpers shall be taken at random and subjected to the tests for visual examination, measurement of diameter, ~~measurement of weight~~, elongation test and chemical composition analysis. After chemical composition analysis by Spectrometer, one sample(one wire) per 10 coils or minimum one sample for less than 10 coils, shall be subjected to Electrolysis Test (IS: 440-1964 or latest) for determination of copper content.

8.2.3 Criteria for acceptance :

8.2.3.1 The samples of wire and conductor taken from each drum shall be subjected to all the tests prescribed in Clause 8.2.1. The wire and conductor in the drum shall be deemed to have passed the tests if the samples pass all the tests. If a sample fails in more than one test, the drum shall be rejected. Should the sample fail in any one of the tests, two more sample shall be taken from the drum and subjected to all the tests. Should any sample fail in any test, the drum shall be rejected.

8.2.3.2 The wires and conductors in the rejected drum shall be cut into lengths of less than 5m to prevent its getting inadvertently mixed with other drums.

9 TEST METHODS

9.1 VISUAL EXAMINATION

When examined visually, the wires and conductor shall be smooth, free from harmful defects such as abrasions, peelings, rough surface and bird caging.

9.2 MEASUREMENT OF DIAMETER OF WIRES AND STRANDED CONDUCTOR

The diameter of wires shall be measured by means of a ratchet micrometer or a dial micrometer between two flat circular studs of minimum diameter of 5mm. The diameter of conductor shall be measured by vernier caliper. The measurement shall be taken at 3 places of the sample. The average diameter of the wires and conductor shall be within the limits prescribed in Clause 5.5 and 6.1respectively.

9.3 MEASUREMENT OF LAY LENGTH

The lay lengths shall be measured for the complete conductor. The lay length of different layers shall be within the limits prescribed in Clause 6.4 and 6.5.

9.4 MEASUREMENT OF WEIGHT

The weight of ~~wires and~~ stranded conductor per km shall be measured by weighing three samples each of 50 cm(approx) length by a balance having accuracy of ± 1 gm ~~for conductor and ±0.1 gm accuracy for wires.~~

9.5 MEASUREMENT OF ELECTRICAL RESISTANCE OF STRANDED CONDUCTOR

The resistance of the stranded conductor shall be measured at room temperature and shall be converted at 20^0C. The value of resistance, obtained by measurement shall not exceed the calculated value of resistance as per Clause 6.1.

9.6 ELONGATION TEST

This test shall be performed only on wires. The load shall be applied on straight lengths of wires having an original gauge length of 250 mm. The extension shall be measured on the gauge length after the fractured ends have been fitted together provided the fracture occurs between the gauge marks and not closer than 25 mm to either mark. If the fracture occurs outside these limits the test shall be discarded and another test conducted.

9.7 CHEMICAL ANALYSIS

The trace elements shall be determined by Spectrometric method. The copper shall be determined in accordance with IS: 440-1964 or latest. The chemical composition shall be as below:

Element	**Percentage**
Cu+Ag	99.90 Min
Bi	0.001
Pb	0.005
Other impurities excluding silver and oxygen	0.03
Oxygen	0.06

10. PROOF OF PURCHASE OF CCR ROD

Supplier shall be required to submit following documents at the time of Acceptance Test which shall be part of Inspection Certificate.

a) Proof of purchase(Invoice) of Continuous Cast Copper Rod.
b) For imported Continuous Cast Copper Rod the Supplier shall submit proof of import i.e.
   i) Bill of Entry.
   ii) Bill of Lading/Air way bill.
   iii) Payment details to overseas Rod manufacturer.
   iv) Declaration that he has and will not use these Documents for any other consignment or purpose.

c) The rod, either Indigenous or imported, has to be procured directly from the manufacturer .
d) Procurement of Rod on Job Work Basis is not allowed
e) Procurement of Rod from indigenous manufacturer is preferable.
f) Procurement of Rod from any distributor/trader/channel partner of manufacturer is not permitted to ensure quality of material.

11 PACKING AND MARKING

11.1 The conductor shall be supplied to the purchaser properly wound on drums. A drum shall carry only one continuous length of conductor. The conductor shall be carefully wound on the drum, the turns being close and continuous without any overriding except on the first and last turns on each layer. Paper shall be provided between each layer of conductor while winding on the drum during manufacturing process.

11.2 The drum shall be of strong construction and shall conform to IS:1778-1980 or latest (Specification for reels and drums for bare conductors). The flanges of the drum shall be large enough to prevent any possible contact between the conductor and the ground during handling or transport. No internal or external lagging is necessary, but wood battens shall be nailed to the flanges covering the whole width of the drum and the full circumference of the flanges.

11.3 The labelling on the drum shall include the following information :

i) Size of the conductor.
ii) Length of the conductor.
iii) Weight of drum (Gross and net weights).
iv) Drum number
v) Name of the Manufacturer
vi) Any other particulars specified by the purchaser.
vii) Purchase Order no. and the name of the consignee.

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