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**GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS**



सत्यमेव जयते

**TECHNICAL SPECIFICATION
FOR
HARD DRAWN GROOVED COPPER CONTACT WIRE
FOR ELECTRIC TRACTION
(DRAWN OUT OF CONTINUOUS CAST COPPER WIRE RODS)**




Issued by

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Specification no. TI/SPC/OHE/CW/0971

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Following clauses will be effective from 3 months from date of issue/effective date of Specification :

Clause 8.2.2 : The Inspector shall check calibration certificate of counter meters of all available contact wire drawing machine, the accuracy and calibration of the counter meters by passing the wire of known length.

Clause 9.2 : The Inspector shall check calibration certificate of counter meters of all available contact wire drawing machine, the accuracy and calibration of the counter meters by passing the wire of known length.

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SPECIFICATION FOR HARD DRAWN GROOVED COPPER CONTACT WIRE FOR ELECTRIC TRACTION (DRAWN OUT OF CCC WIRE RODS)

1.0 SCOPE

1.1 This Specification covers the requirement of hard drawn grooved copper(HDGC) contact Wire manufactured from Continuous Cast Copper (CCC) Wire Rods for Electric Traction overhead lines.

1.2 Old Specification no. ETI/OHE/76(6/97) is re-designated and updated to TI/SPC/OHE/CW/0971 in-line with TI document no. TI-WI-7.5.1- 1 ver 1.0.

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

2.0 GOVERNING SPECIFICATIONS

2.1 In the preparation of this specification assistance has been taken from the following standards and specifications.

2.1.1	IS: 191-2007 or latest.	Specification for Copper.
2.1.2	IS: 1778-1980 or latest.	Specification for Reels and drums for bare conductors.
2.1.3	IS: 1885 (Pt.xxxii)-2019 or latest.	Electro-technical Vocabulary (Electric cables)
2.1.4	IS: 9713-1983 or latest.	Specification for Hot Rolled Electrolytic Copper Wire Rods for Electrical Conductors.
2.1.5	IS: 440-1964 or latest.	Methods of chemical analysis of Copper.
2.1.6	NEMA WC 26-2008 or latest.	Binational Wire and Cable Packaging Standard.

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

2.3 Any deviation from this specification proposed by the **manufacturer** to improve upon the performance of Contact Wire shall be considered only on its merits provided full particulars with justification and financial implication are furnished by the **manufacturer**.

2.4 For the purpose of this specification, the definitions given in IS:1885(Part xxxii)-2019 or latest shall apply.

3.0 ENVIRONMENTAL CONDITIONS

- 3.1 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 in TABLE – 1.

TABLE – 1
ENVIRONMENTAL CONDITIONS

SN	Environmental condition	Limits
i.	Ambient air Temperature.	0° C to +50° C
ii.	Maximum temperature of metallic object under sun.	70° C
iii.	Minimum temperature.	-10° C
iv.	Maximum relative humidity	100%
v.	Annual Rainfall	1750 mm to 6250 mm.
vi.	Maximum number of thunder storm days per annum.	85
vii.	Maximum number of dust storm days per annum.	35
viii.	Number of rainy days per annum	120
ix.	Basic wind pressure	216 kgf/m ²
x.	Altitude	2500 m above mean sea level.

4.0 MATERIAL

- 4.1 The HDGC Contact wire shall be drawn out of indigenous or imported CCC wire rods manufactured by South Wire process of diameter as given in Table-3.
The composition of the CCC wire rod & Contact wire shall be as given in Table-2.

Copper used, should be Electrolytic Grade Copper cathodes conforming to the requirement of LME Grade 'A' copper as listed in the London Metal Exchange. Grade 'A' copper conforming to the chemical composition of Cu-Cath-1 of IS 191: 2007 or latest.

Procurement of CCC wire rod on job work basis is not allowed.

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TABLE – 2

CHEMICAL COMPOSITION OF CCC ROD

Element	% ppm
Cu+Ag	99.95% min
Bi	< 2 ppm
Te	< 2 ppm
Se	< 2 ppm
Bi+Te+Se	< 3 ppm
Pb	< 5 ppm
Sb	< 4 ppm
As	< 5 ppm
Fe	< 10 ppm
S	< 15 ppm
Sn+Ni+Fe+Si+Zn+Co	< 20 ppm
Cr+Mn+Sb+Cd+As+P	< 15 ppm
Oxygen	200 to 350

5.0 PHYSICAL CONSTANTS OF HDGC CONTACT WIRE

5.1 HARD DRAWN COPPER

5.1.1 VOLUME RESISTIVITY

The resistivity of HDGC Contact Wire is a function of the tensile strength. Within a range of 30 – 50 kg/mm² tensile strength, the following formula has been found to express sufficiently closely the results obtained in practice and been adopted in calculating the resistance specified in IS : 3476-1986 or latest.

$$P = T/16$$

Where

P= Percentage increase in resistivity of the hard drawn copper over its resistivity when annealed and

T = Tensile strength of the hard drawn copper in kg/mm².

5.1.1.1 The resistances given in the TABLE-3 are based on standard resistivity of annealed high conductivity Copper at 20°C modified in accordance with the above formula.

5.1.1.2 At a temperature of 20°C the volume resistivity of standard annealed Copper is $1/58 = 0.017241$ ohm mm²/m.

5.1.1.3 Copper which has a resistivity at 20°C of $1/58 = 0.017241$ ohm mm²/m is said to have a conductivity of 100%.

5.1.2 DENSITY

At a temperature of 20°C the density of hard drawn high conductivity Copper has been taken as 8.89 g/cm³.

5.1.3 CO-EFFICIENT OF LINEAR EXPANSION

At a temperature of 20°C the co-efficient of linear expansion of hard drawn high conductivity copper has been taken as 0.000017 per °C. This co-efficient may be used over a temperature range from 0°C to 150°C.

5.1.4 CONSTANT MASS TEMPERATURE CO-EFFICIENT OF RESISTANCE

At a temperature of 20°C, the co-efficient of variation of the resistance with temperature of hard drawn high conductivity Copper, measured between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, has been taken as 0.00381 per °C which is a representative value of copper of 97% conductivity.

6.0 SIZES, SHAPES, DIMENSIONS, WEIGHTS AND OTHER PROPERTIES OF CONTACT WIRE

- 6.1 The various sizes, shapes and dimensions for the Contact Wire shall be as indicated in Figure – 1,2 & 4.
- 6.2 The cross-sectional areas, weights, maximum resistances and other properties shall be as detailed in TABLE – 3. Tolerance on weight shall be +/- 3.0% in case of 107 mm² and 150 mm² contact wire and +/- 2.0% in case of 161 mm² & 193 mm² contact wire.

TABLE – 3
PROPERTIES OF HARD DRAWN COPPER CONTACT WIRE

Cross Section	Dia of CCC rod		Standard weight/ Km	Resistance/ km at 20°C	Tensile strength	Conventional limit of elasticity	Elongation in 200 mm	Nos of bending	Hardness
1	2		3	4	5	6	7	8	9
Nom	Min	max	Nom.	Max.	Min.	Min.	Min.	Min.	Min.
Mm ²	Mm	mm	kg	Ohms	Kgf/mm ²	Kgf/mm ²	%	Nos	BHN
107	19.1	21.5	951.2	0.1660	36.5	31.0	3	7	107
150	22.5	26.5	1333.5	0.1184	36.5	31.0	3	6	107
161	23.0	26.5	1431.3	0.1103	36.5	31.0	3	6	107
193	23.0	26.5	1715.8	0.0921	36.5	31.0	3	5	107

Note

- i) Values given in column-3 & 4 correspond to Nominal cross-sectional area of HDGC Contact Wire.

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- ii) Minimum diameter of CCC wire rod, achieved for 193 mm² HDGC Contact wire(column 2), is based on single type test conducted on 23.0 mm diameter CCC wire rod of M/s Carlo Colombo, SPA Italy.
- iii) The conventional limit of elasticity indicated in column 5 is for information only. The conventional limit of elasticity is defined as the maximum tensile load which the test piece may withstand for a period of 10s without under-going a permanent elongation of more than 0.2% of the original gauge length.

6.3 MECHANICAL AND ELECTRICAL PROPERTIES

- 6.3.1 The tensile strength, elongation, hardness and number of bending when tested in accordance with Clauses 9.5.6, 9.5.7 and 9.5.9, shall not be less than the appropriate values given in TABLE-3. The Contact Wire shall also comply with the requirements of the bending test specified in Clause 9.5.8.
- 6.3.2 The Electrical Resistance per Kilo meter of the sample, multiplied by the appropriate constant in TABLE-5 and corrected for the cross-sectional area, shall not exceed the values given in TABLE-3.

6.4 JOINTS

There shall be no joints in CCC rod and Contact Wire made out of CCC wire rods.

6.5 FREEDOM FROM DEFECTS

- 6.5.1 The Contact Wire shall be clean, smooth and free from harmful defects, such as scales, peelings, sharp edges and defects in the groove.
- 6.5.2 The groove shall be uniform and free from twists. Any defect in the groove noticed at the time of or subsequent to erection of the Contact Wire shall entail heavy penalty on the manufacturer. To check on this, suitable means shall be employed by the manufacturer by way of provision of a mirror or other suitable means and monitor during the drawing out of the Contact Wire.
- 6.6 The wire drawing of Contact Wire shall be done by 4 or 5 stage wire drawing machine.

7.0 TESTS

- 7.1 After a purchase order is placed for supply of wire for overhead Railway Traction, the internal test results for all the tests specified in clauses-8.1 & 9.1 shall be furnished by the successful manufacturer to the Director General (TI)/RDSO within the period stipulated for prototype approval in the order

- 7.2 Any changes required to be done in the prototype as required by the Director General (TI)/RDSO shall be carried out expeditiously by the manufacturer.
- 7.3 **Type-Testing Schedule:-** Prior to giving a call to the Director General (TI)/RDSO for inspection and testing of the prototype, the 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 Wire Rod/Contact Wire so as to test Wire Rod/Contact Wire 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 Director General (TI)/RDSO, whose decision shall be final and binding.
- 7.4 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.
- 7.5 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 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, 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 Director General (Traction Installation), Research Designs & Standards Organisation, Lucknow shall be paid through a demand draft as advised to the manufacturer.
- 7.6 **BULK MANUFACTURE**
- Only after clear written approval of the results of the tests on the prototype is communicated by the Director General (TI)/RDSO to the manufacturer, manufacturer shall take up bulk manufacture of the Contact Wire which shall be strictly with the same material and process as adopted for the prototype.
- 7.7 **TECHNICAL DATA**

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The **manufacturer** shall furnish along with the offer the guaranteed performance data and other technical particulars of the Contact Wire. The guaranteed values shall have to be proved by test.

8.0 TESTS ON CCC WIRE RODS

8.1 TYPE TESTS

8.1.1 The following type tests shall be carried out on three samples of the CCC wire rods taken in accordance with IS : 191-2007 or latest.

- i) Visual Examination
- ii) Measurement of dimensions
- iii) Compression Test
- iv) Tensile strength/elongation Test
- v) Chemical composition
- vi) Micro-structure examination
- vii) Ultrasonic testing at the time of wire drawing
- viii) Electrical Resistivity Test

8.2 ACCEPTANCE TESTS

8.2.1 "CUSTOMER HOLD POINT(CHP)"

The manufacturer shall include in his quality assurance plan (QAP) a CHP stage beyond which the manufacturing process shall proceed only after CCC wire rods pass the acceptance test duly verified by the Designated Authority in accordance with Clause No.8.2.2.

The QAP shall have the approval of the Director General (TI), RDSO before taking up the manufacture.

8.2.2 The following tests shall be carried out on in accordance with **TI/SPC/OHE/CCC/0871** on the samples of CCC wire rods drawn in accordance with IS: 9713-1983 or latest (for the purpose of sampling only).

- i) Visual Examination
- ii) **Measurement** of dimensions
- iii) Compression Test
- iv) Tensile strength/elongation Test
- v) Chemical Composition
- vi) **Micro-structure Examination**
- vii) Electrical resistivity test

In addition weighment of every empty drums (to be used for Contact Wire) for tare weight, either at the time of stage inspection/Acceptance Test of CCC Rods or on call given by the manufacturer. Identification mark with Tare weight should be provided by Inspecting official on each drum. Record of the result of weighment shall be maintained.

The Inspector shall verify physical raw material purchased by the supplier with the copy of its invoice. Inspector shall check with CCC rod, coil no./batch no. mentioned in raw material purchase invoice are actually matching with raw material. Record of the invoices shall be maintained.

The Inspector shall check calibration certificate of counter meters of all available contact wire drawing machine, the accuracy and calibration of the counter meters by passing the wire of known length.
[Effective from 01.04.2021]

8.3 MANUFACTURER'S TESTS

8.3.1 The manufacturer shall test all the CCC wire rods for visual examination and measurement of dimensions. All the wire rods shall be free from any piping, crow feet, indentation, foreign particles or inclusions, surface defects, twists and entanglements.

8.3.2 The manufacturer shall test every lot of CCC wire rods for tensile/elongation and compression. These tests shall be carried out on the samples of wire rods drawn in accordance with IS : 9713-1983 or latest. A lot shall be as stipulated in IS : 9713-1983 or latest.

8.3.3 The manufacturer shall test every lot of CCC wire rods for chemical composition and micro-structure examination. The samples will be drawn in accordance with IS : 9713-1983 or latest.

8.3.4 Records of the results of the tests shall be maintained by the manufacturer and checked by the Inspector.

8.4 CRITERIA FOR ACCEPTANCE

8.4.1 Criteria for acceptance of the lot shall be in accordance with Clause-9 of IS : 9713-1983 or latest.

8.5 METHODS OF TESTS

8.5.1 VISUAL EXAMINATION

The surface of CCC wire Rod shall be fairly smooth, free from inclusions or foreign particles, indentation, surface defects, scales, twists, entanglements etc.

8.5.2 MEASUREMENT OF DIMENSIONS

Discard approximately 2.5 meter length from the end of the coil. Three measurements at 60° angular displacement shall be made around the circumference at two places 4 meter apart. An average of six readings shall be considered as the diameter of the CCC wire rod. The diameter shall be as per column 2 of Table 3 of clause 6.2.

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8.5.3 COMPRESSION TEST

A sample of length twice the diameter of the CCC rod shall be cut from the coil and then hammered till its length becomes half the original length. Curved surface, after test, shall not show any crack or defect on visual check.

8.5.4 TENSILE STRENGTH/ELONGATION TEST

When tested in accordance with IS: 1608-Part 1:2018 or latest "Metallic Materials-Tensile Testing-Method of Test at Room Temperature" for tensile strength and elongation, the material shall have a tensile strength of 20.4 kgf/mm² (min.) and a minimum of 46% elongation. But the gauge length of the sample for this test shall be of 250 mm.

8.5.5 CHEMICAL COMPOSITION

The material shall have the chemical composition as given in Table-2. The trace elements shall be determined by Spectrometric method. The copper shall be determined in accordance with IS: 440-1964 or latest. Oxygen content shall be determined by using Spectrometer or Oxygen analyzer.

8.5.6 MICRO-STRUCTURE EXAMINATION

The sample of CCC Wire Rod cut along transverse section polished and etched shall show equiaxed re-crystallised fine grains having grain size finer than ASTM-5. The presence of cast columnar grains in the micro-structure shall not be permitted.

8.5.7 ULTRASONIC TEST

The CCC Wire Rod shall be ultrasonically tested by the manufacturer continuously during production of Contact Wire for the entire length. The defect if any, observed shall require that complete rod to be discarded. Records shall be maintained for the purpose and produced before the inspector on demand. The Contact Wire drawing machine should stop automatically if any defect is observed during ultrasonic testing.

8.5.8 ELECTRICAL RESISTIVITY TEST

Electrical Resistivity of CCC rod shall be determined in accordance with IS 613-2000 or latest. Resistivity shall not be greater than 0.01737 ohm mm²/m at 20°C.

8.6 PROOF OF PURCHASE OF CCC ROD

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

- I. Proof of purchase(Invoice) of CCC Wire Rod from the approved Vendor and Test Certificate.
- II. For imported CCC Wire 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 CCC Wire Rod manufacturer.
 - iv) Declaration that he has and will not use these Documents for any other consignment or purpose.
- III. The CCC wire rod, either Indigenous or imported, has to be procured directly from the manufacturer who is South Wire Licensee.
- IV. Procurement of CCC Rod on Job Work Basis is not allowed.
- V. Procurement of CCC rod from indigenous manufacturer is preferable.
- VI. Procurement of CCC rod from any distributor/trader/channel partner of manufacturer is not permitted to ensure quality of material.
- VII. Inspecting Engineer shall verify the authenticity of proof of purchase from OEM.

9.0 TESTS ON CONTACT WIRE

9.1 TYPE TESTS

The CCC rods shall be drawn into the prototype Contact Wire in presence of the Inspector. The following tests shall be carried out on the samples cut at random from the Contact Wire coil produced. Each test shall be conducted on three samples.

- 9.1.1 Visual examination.
- 9.1.2 Verification of dimensions.
- 9.1.3 Measurement of weight.
- 9.1.4 Electrical resistance test.
- 9.1.5 Hardness test.
- 9.1.6 Tensile test.
- 9.1.7 Elongation test.
- 9.1.8 Bending test.
- 9.1.9 Chemical analysis.
- 9.1.10 Micro-structure examination.
- 9.1.11 Ultrasonic testing of Contact wire

9.2 ACCEPTANCE TESTS

Same as type tests except that indicated in Clause 9.1.11 In addition weighment of each offered Contact Wire drums for acceptance tests, for gross weight. The Inspector shall verify the results of manufacturer's tests.

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The Inspector shall check calibration certificate of counter meters of all available contact wire drawing machine, the accuracy and calibration of the counter meters by passing the wire of known length.
[Effective from 01.04.2021]

9.3 ROUTINE TESTS

- 9.3.1 Visual examination.
- 9.3.2 Verification of dimensions.
- 9.3.3 Measurement of weight.
- 9.3.4 Tensile test.
- 9.3.5 Elongation test.
- 9.3.6 Bending test.
- 9.3.7 Oxygen Content

9.4 MANUFACTURER'S TESTS

- 9.4.1 The manufacturer shall test every lot of CCC wire rod for chemical composition. A lot shall be as stipulated in IS : 9713-1983 or latest. The results shall be checked by the Inspector.
- 9.4.2 Every CCC wire Rod shall be thoroughly inspected for blow holes, pipes, oxide-inclusions and other defects before drawing. In case of defects wire rod shall be rejected.
- 9.4.3 The manufacture shall weigh every drum for tare weight and gross weight. Records of the results of weighment shall be checked by the Inspector at the time of Acceptance Tests.

9.5 TEST METHODS

9.5.1 MICRO-STRUCTURE EXAMINATION OF CONTACT WIRE

A sample of the finished Contact Wire shall be transversely sectioned, polished and etched and it shall show equi-axed re-crystallised fine grain structure to ASTM No.7 or finer. Presence of cast columnar grains or dendritic structure representing improper breakdown of the original structure will not be permitted.

9.5.2 CHEMICAL ANALYSIS

The samples taken from the Contact Wire shall be tested for chemical composition in accordance with Clause 8.5.5 of this specification. The chemical composition shall be as per Table-2.

9.5.3 VISUAL EXAMINATION

The surface finish of the grooved Contact Wire shall be checked for defects, such as chips, scales, sharp edges, bubbles, peelings, scratches, pin holes. The Contact Wire shall have no twists or kinks.

9.5.4 VERIFICATION OF DIMENSIONS

9.5.4.1 The diameter of the grooved Contact Wire shall be measured by means of a ratchet micrometer or a dial micrometer between two circular flat studs having a diameter of not less than 5 mm. The value of the diameter shall be the mean of two readings made in two directions perpendicular to each other and situated approximately at the same cross section.

9.5.4.2 CHECKING OF DIMENSIONS AT THE BOTTOM OF THE GROOVE

The dimensions at the bottom of the groove in the Contact Wire shall be measured by means of either a special caliper made in accordance with Fig.2 or by shadowgraph projection of not less than 10X. The method shall be subject to agreement between the purchaser and the manufacturer.

The dimension shall be as given in Figure 1.

9.5.5 MEASUREMENT OF WEIGHT

The weight of the Contact Wire, per km shall be calculated by weighing a piece of 50 cm length by a balance of accuracy of $\pm 1\text{gm}$, by a digital balance. The weight of the Contact Wire shall be as specified in TABLE-3. Tolerance on weight shall be $\pm 3\%$.

9.5.6 TENSILE TEST

A sample of Contact Wire which is straight and of length such that when it is held in the jaws of the Tensile Testing Machine the distance between the jaws is not less than 250mm shall be taken. A gauge length of 200mm shall be marked on the test piece for the purpose of measuring the elongation. The load shall be applied gradually until the test piece breaks. The tensile strength of the Contact Wire shall be not less than values specified in TABLE-3.

9.5.7 ELONGATION TEST

The elongation shall be measured on the same test piece which was subjected to tensile test upto its fracture as specified in Clause- 9.5.6. The elongation of the sample after tensile test shall be measured with reference to the gauge length after the fractured ends have been fitted together provided fracture occurs within the gauge length. The values of percent elongation measured shall be not less than the values specified in TABLE-3. If the fracture occurs outside the gauge length and the required elongation is not achieved, another sample shall be tested. If this sample also fails, the lot shall be rejected.

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9.5.8 BENDING TEST

The test consists of bending by hand/machine, a straight length of 200 mm long Contact Wire through 90° and back, alternately on either side of the vertical with the axis of the straight and bent portions of the Contact Wire remaining in the same plane. The test piece shall be held in blocks of the type shown in Fig.3 having a radius of 30 mm. A tube whose inside diameter is slightly higher than the diameter of the Contact Wire and one end of which is closed shall be put over the contact wire, the lower end of the tube being about 20 mm above the surface of the blocks. The first bending operation shall be carried out in a direction such that the top lobe of the wire is in tension. One bend shall be construed as including all operation between two consecutive passages of the test piece through the vertical position. During each bending operations the entire length of the Contact Wire and in particular the length adjacent to the clamping plane shall touch the face of the block on the side to which the Contact Wire is bent. There shall not be any twisting of the wire during bending. There shall not be more than one bending operation per second. The test piece shall withstand the appropriate number of bends indicated in TABLE-3 without fracture. One bend consists of bending the free end of the test specimen through 90° and returning it to its original position.

9.5.9 HARDNESS TEST

Hardness of sample of Contact Wire shall be determined on Brinell Scale with 2.5 mm dia. balls and load of 62.5 kg. in accordance with IS: 1500-Part 1:2019 "Metallic Material- Brinell Hardness Test-Test Method". The hardness shall be measured at mid radius of the cross section of Contact Wire and average of 3 such values shall be considered for qualifying purpose. The hardness of the Contact Wire shall be not less than values specified in TABLE-3.

9.5.10 ELECTRICAL RESISTANCE TEST

The electrical resistance of three samples shall be measured by means of a double Kelvin Bridge. The current terminals shall be sufficiently away from the voltage terminals. The electrical resistance of test sample multiplied by $W \times C/K$ shall not exceed the appropriate values indicated in TABLE-3.

Where

W = weight per km of test sample in kg

K = standard weight of Contact Wire per km in kg

C = multiplying constant for temperature variation indicated in

TABLE-5.

Note : The Inspector shall check the accuracy and calibration of the measuring equipment by resistance of known value.

9.5.11 The contact wire shall be ultrasonically tested by the manufacturer continuously during production for the entire length. The defect if any, observed shall require that entire tension length of Contact wire to be discarded. Records shall be maintained for the purpose and produced before the inspector on demand. The Contact Wire drawing machine should stop automatically if any defect is observed during ultrasonic testing.

9.6 SELECTION OF SAMPLE FOR TESTS & CRITERIA OF APPROVAL

9.6.1 BATCHES

9.6.1.1 The Contact Wire shall be offered for inspection in a batch of 6 drums at a time.

Each drum of 193 mm² HDGC Contact wire drawn out of 23 mm diameter(min.) CCC wire rod shall be tested for Hardness and Tensile Test, during "Acceptance Test".

9.6.2 One sample of Contact Wire shall be cut from each drum in the presence of the Inspector for the tests. No treatment shall be given to any sample before tests except that it may be straightened, if necessary.

9.6.3 Three samples of Contact Wire shall be subjected to acceptance tests as given below :

9.6.3.1 Visual examination.

9.6.3.2 Verification of dimensions.

9.6.3.3 Measurement of weight

9.6.3.4 Electrical resistance test.

9.6.3.5 Hardness test.

9.6.3.6 Microstructure examination

Thereafter one sample from each drum shall be subjected to the following tests:

9.6.3.7 Tensile and Elongation Tests.

9.6.3.8 Bending Test.

9.6.3.9 After destruction one of the sample shall be subjected to the chemical composition test.

9.6.3.10 Acceptance of records maintained for tests in accordance with 8.5.7 & 9.5.11 will form a part of the acceptance tests for the Contact Wire.

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- 9.6.4 Should a sample of Contact Wire fail in any one of the test, a second sample of the Contact Wire shall be taken from the same drum from which the sample which had failed was taken. This sample shall be subject to the same test in which the first sample had failed. If the second sample passes the test the batch shall be deemed to have complied with the requirement of this clause. Should failure occur in more than one test, the batch shall be deemed to be rejected.

10.0 PACKING AND MARKING

10.1 PACKING OF CCC Wire RODS

The material shall be supplied in coils strapped with loops or as required by the Purchaser.

10.2 MARKING OF CCC ROD COILS

On the coil suitable tags with markings made on them shall be provided with each coil and shall carry the following information.

- i Name and trade mark of manufacturer
- ii Size of wire rod, weight and length of coil
- iii Lot number and Written submission of declaration from the manufacturer regarding use of CCC Rod with proof of purchase along with relevant documents
- iv Date of manufacture
- v Purchase order number and name of consignee:
- vi Date of inspection and inspecting authority
- vii Any other information required by the purchaser.

10.3 PACKING AND MARKING OF CONTACT WIRE

10.3.1

- i) The contact wire shall be supplied properly wound on either wooden drums or corrugated steel drums (type of drum required whether wooden or steel to be specified by the purchaser in his purchase order) in specified lengths as required by the purchaser, the turns of the wire being close and continuous without any overriding except on the first and last turns of each layer.
- ii) A drum shall carry only one continuous length of contact wire.
- iii) In order to avoid any damage to Contact Wire, corrugated paper sheet of min. 3.00 mm thickness shall be provided on the outer diameter of barrel & at the top layer of Contact wire, after winding of entire length has been completed.
- iv) Inner side of flanges shall also be provided with corrugated paper sheet of Min. 3.00 mm thickness pasted/tied to flange.
- v) Top surface of finished drum shall also be provided with plastic sheet for additional protection. On top of plastic sheet, additional

corrugated paper sheet to be provided for enhanced protection to Copper Conductor before final packing.

vi) Any damage in the Contact Wire shall be to supplier's account.

10.3.2 The Contact Wire shall be so wound on the drum that the top (smaller) lobe of the Contact Wire is on the top. The manufacturer shall ensure that the top and the bottom lobes of the Contact Wire are not disturbed during winding on the drum and the Contact Wire is not twisted to change the orientation of the top lobe on the drum.

10.3.3 The length of the Contact Wire for each drum shall be specified by the purchaser. The specified length shall not be more than 2000m.

10.3.4 The length of the Contact Wire in a drum, after the test pieces required for the various tests have been cut and taken out shall be not less than values specified by the purchaser.

10.3.5

i) The wooden drum shall comply with IS: 1778-1980 or latest "Specification for Reels and Drums for bare conductors" and shall have the dimensions as indicated in TABLE-4.

TABLE - 4

DRUM DIMENSION FOR DIFFERENT SIZE OF CONTACT WIRE

Size of Contact Wire (mm ²)	Length Contact (m)	of* Wire	Flange** dia(mm)	Barrel dia (mm)	Traverse (mm)	Remarks
107	1600		1530	1200	600	
107	2000		1575	1200	600	
150	1500		1575	1200	600	
150	2000		1650	1200	600	
161	1500		1650	1200	600	
161	2000		1750	1200	600	
193	1600		1750	1200	600	
193	2000		1830	1200	600	

*These are higher limits which may not exceed by more than 50mm.

** Flange diameter subject to a maximum of 1900mm.

ii) Corrugated Steel drums shall be of maximum capacity 3570 Kg as per Table 2.2 type RM of NEMA WC 26-2008 or latest . Size of the selected drum for 107 mm² (HDGC) Contact Wire is as per table below:

Flange	Barrel Dia	Traverse
72 inch	48 inch	36 inch

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1828.8 mm	1219.2 mm	914.4 mm
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- iii) Gross Weight of Steel Drum specified in Para (ii) above, after winding contact wire shall be limited to 2800 kg.

10.3.6 Each drum of Contact Wire shall be provided with two colour bands alternatively each of red and yellow paint of approximately 75mm width each, at the top layer of Contact Wire for identification. Top end of the Contact Wire shall also be provided with lead seal by inspection authority by making hole in the Contact Wire, in addition to punch mark provided by the manufacturer for identification of end. On receipt of Contact Wire drums the colour bands, sealing at the end of Contact Wire and punch mark shall be verified by the consignee to ascertain correct receipt of length of Contact Wire.

10.3.7 The emblem/identification mark of the Contact wire manufacturer and CCC Rod manufacturer with year of manufacture in 3 mm letter size shall be provided on the top lobe of the Contact Wire on regular intervals – not less than 40m and not exceeding 50m so as to facilitate identification. The marking shall be provided in the format mentioned in Clause 10.3.8 below and shall be such that it is not detrimental to the strength of the Contact Wire.

10.3.8 The identification mark in format CCC/MMM/YY shall be provided as mentioned in Clause 10.3.7 above.

Where, First abbreviation i.e CCC shall indicate identification for manufacture of CCC rod Followed by slash

Second abbreviation i.e 'MMM' shall indicate identification for manufacture of Contact wire followed by slash

Third abbreviation i.e 'YY' shall indicate year of manufacture for example 80 for 1980 and 10 for 2010.

The abbreviation for manufacturer should be first three alphabets of Vendor name as indicated in Vendor Directory against each firm.

10.3.9 The following particulars shall be marked in indelible paint on each drum:

- i Purchaser's order number.
- ii Size of Contact Wire.
- iii Length of Contact Wire.
- iv Gross and net weights.
- v Drum number and
- vi Consignee and other particulars as required by the purchaser.
- vii Make, batch no. and month & year of procurement of CCC rod.

11.0 DISPOSAL OF REJECTED CONTACT WIRE

Contact Wire which is rejected shall be cut into pieces of length not greater than 300 m or drawn again into thinner wire. This shall be done in the presence of the Inspector.

TABLE – 5
MULTIPLIER CONSTANT FOR HARD DRAWN COPPER WIRE

Multiplying constant and its reciprocal for converting resistance of copper Contact Wire at various temperatures to that at standard temperature of 20° C and to that and for converting resistance at 20°C to that at any other temperature respectively:

Temperature °C	Multiplier Constant	Reciprocal of constant
5.0	1.0606	0.9429
5.5	1.0585	0.9448
6.0	1.0563	0.9467
6.5	1.0542	0.9486
7.0	1.0521	0.9505
7.5	1.0500	0.9524
8.0	1.0479	0.9543
8.5	1.0458	0.9562
9.0	1.0437	0.9581
9.5	1.0417	0.9600
10.0	1.0396	0.9524
10.5	1.0376	0.9638
11.0	1.0355	0.9657
11.5	1.0335	0.9676
12.0	1.0314	0.9695
12.5	1.0294	0.9714
13.0	1.0274	0.9733
13.5	1.0254	0.9752
14.0	1.0234	0.9771
14.5	1.0214	0.9790
15.0	1.0194	0.9810
15.5	1.0174	0.9829
16.0	1.0155	0.9848
16.5	1.0135	0.9867
17.0	1.0116	0.9886
17.5	1.0096	0.9905
18.0	1.0077	0.9924
18.5	1.0057	0.9943

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19.0	1.0038	0.9962
19.5	1.0019	0.9981
20.0	1.0000	1.0000
20.5	0.9981	1.0019
21.0	0.9962	1.0038
21.5	0.9943	1.0057
22.0	0.9924	1.0076
22.5	0.9996	1.0095
23.0	0.9887	1.0114
23.5	0.9868	1.0133
24.0	0.9850	1.0152
24.5	0.9831	1.0171
25.0	0.9813	1.0191
25.5	0.9795	1.0210
26.0	0.9777	1.0229
26.5	0.9758	1.0248
27.0	0.9740	1.0267
27.5	0.9722	1.0286
28.0	0.9704	1.0305
28.5	0.9680	1.0324
29.0	0.9668	1.0343
29.5	0.9651	1.0362
30.0	0.9633	1.0381

NOTE – 1: If the resistance of Contact Wire at T°C is measured, the resistance at 20°C is obtained by multiplying the resistance at T°C by the multiplying constant against the value of T°C given in column 2. If the resistance at 20°C is known, the resistance at T°C is obtained by multiplying the resistance at 20°C by reciprocal indicated against T°C given in column 3.

NOTE – 2: The temperature co-efficient of resistance of copper varies slightly from sample to sample according to its conductivity. The figures given above are based on a co-efficient of 0.00381 per °C at 20° C which is an average value for copper of 97% conductivity. The error in using this for copper in the range of conductivity of 96% to 98% will not exceed 0.06%.

12.0 All the provisions contained in RDSO's ISO procedure laid down in document no. QO-D-8.1-11 dated 01.07.2020 or latest (Title "Vendor-change in approved status") and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendor/vendors in the contracts floated by Railways to maintain quality of the products supplied to Railways.

13.0 SCHEDULE OF GUARANTEED TECHNICAL PARTICULARS

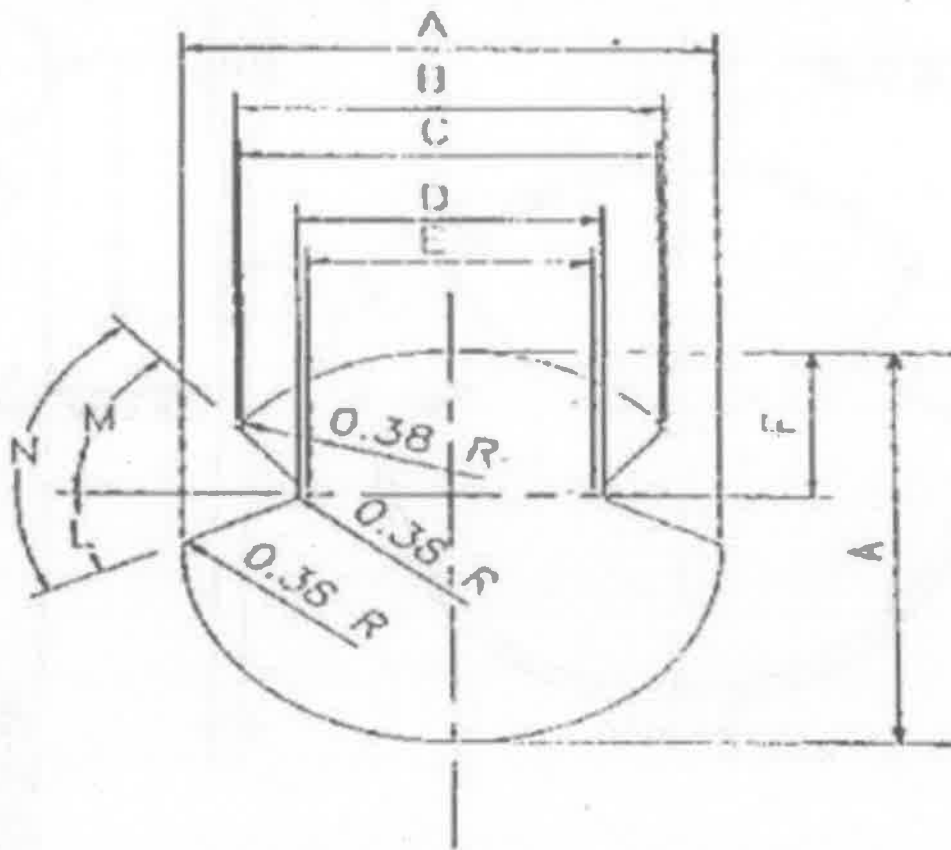
The Schedule of guaranteed technical particulars (SOGP) for Hard Drawn Grooved Copper Contact Wire for overhead electric traction drawn out of CCC rods.

S.N.	Item description	Unit of measurement	Value as per RDSO's specification	Offered value by tenderer
1	Chemical composition of CCC Rod & Contact Wire			
	Element	% ppm		
	Cu+Ag	%	99.95% min	
	Bi	ppm	< 2 ppm	
	Te	ppm	< 2 ppm	
	Se	ppm	< 2 ppm	
	Bi+Te+Se	ppm	< 3 ppm	
	Pb	ppm	< 5 ppm	
	Sb	ppm	< 4 ppm	
	As	ppm	< 5 ppm	
	Fe	ppm	< 10 ppm	
	S	ppm	< 15 ppm	
	Sn+Ni+Fe+Si+Zn+Co	ppm	< 20 ppm	
	Cr+Mn+Sb+Cd+As+P	ppm	< 15 ppm	
	Oxygen	ppm	200 to 350 ppm	
2	Maximum resistivity of CCC rod at 20°C	ohm mm ² /mm	0.01737	
3	Minimum tensile strength of CCC rod	kgf/mm ²	20.4	
4	Minimum elongation on gauge length of 250mm	%	46	
5	Min. & max. dia of CCC rod for manufacturing following size contact wire	mm	Diameter of CCC Rod	
	107 sq.mm		19.1 to 21.5	
	150 sq.mm		22.5 to 26.5	
	161 sq.mm		23.0 to 26.5	
	193 sq.mm		23.0 to 26.5	
6	Grain size number of micro structured CCC rod.	Number (Unit)	Equiaxed re-crystallised fine grains having grain size finer	

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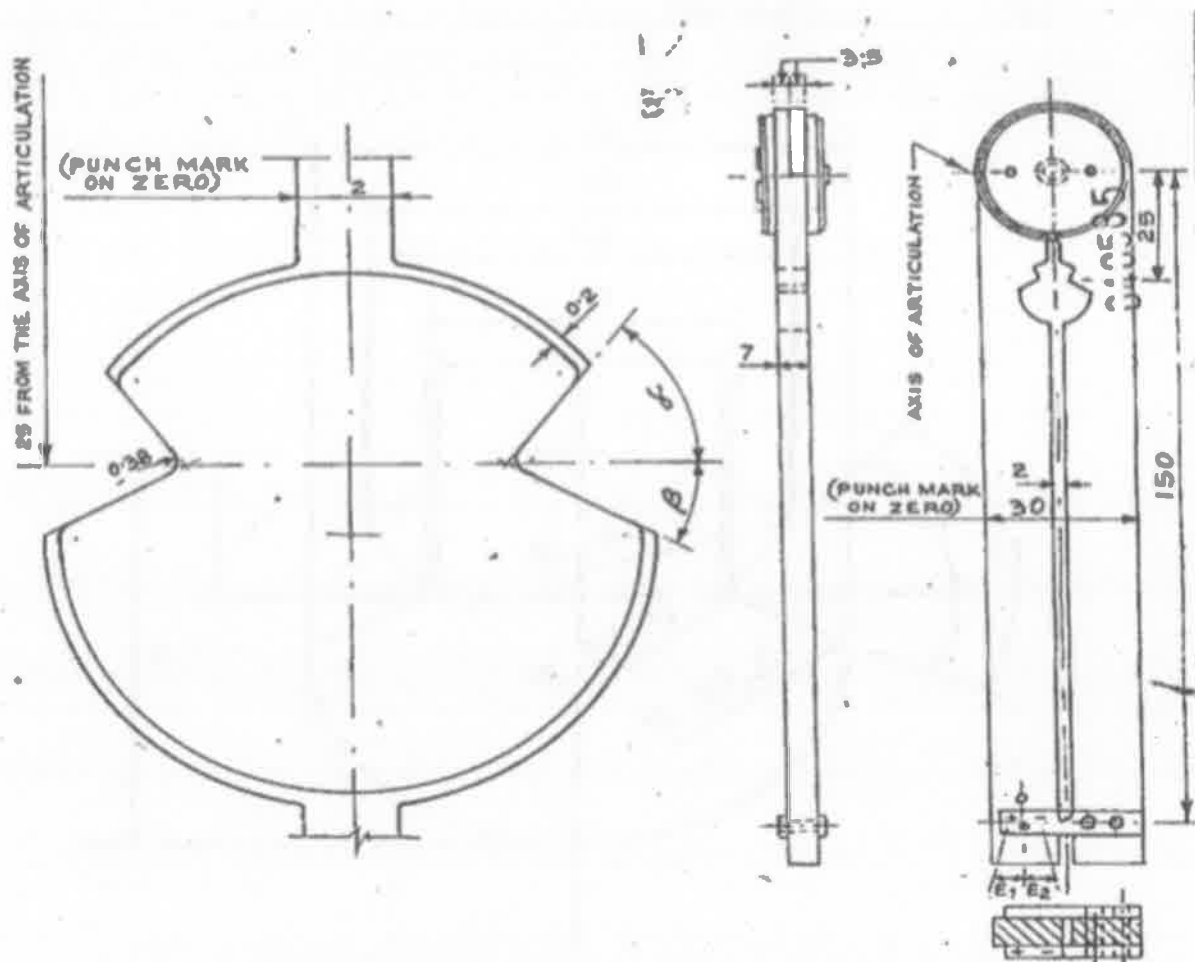
			than ASTM-5	
7	Standard weight/ km of HDGC Contact Wire			
	107 sq.mm	Kg	951.2 ±3.0%	
	150 sq.mm		1333.5±3.0%	
	161 sq.mm		1431.3±2.0%	
	193 sq.mm		1715.8±2.0%	
8	Resistance /km of HDGC Contact Wire at 20°C			
	107 sq.mm	Ohm	0.1660 (max.)	
	150 sq.mm		0.1184 (max.)	
	161 sq.mm		0.1103 (max.)	
	193 sq.mm		0.0921(max.)	
9	Minimum tensile strength of HDGC Contact Wire	Kgf/mm ²	36.5	
10	Minimum elongation of HDGC Contact Wire in 200 mm	%	3	
11	Min. conventional limit of elasticity (theoretical value for information only)	Kgf/mm ²	31.0	
12	Min. No. of bends of HDGC Contact wire to withstand with			
	107 sq.mm	Nos	7	
	150 sq.mm		6	
	161 sq.mm		6	
	193 sq.mm		5	
13	Minimum hardness of HDGC Contact Wire	BHN	107	
14	Grain size number of micro-structured Contact Wire	Number (Unit)	Equiaxed re-crystallised fine grains having grain size finer than ASTM-7	
15	Diameter of HDGC Contact Wire:			
	107 sq.mm	mm	12.24±0.16	
	150 sq.mm		14.50±0.20	

	161 sq.mm		15.00±0.15	
	193 sq.mm		16.4±0.15	
16	Thickness of HDGC Contact Wire at groove.			
	107 sq.mm	mm	6.92+0.15	
	150 sq.mm		6.92+0.15	
	161 sq.mm		8.50+ 0.18 - 0.30	
	193 sq.mm		8.50+ 0.18 - 0.30	
17	Angle of groove of HDGC Contact Wire			
	107 sq.mm	Degree	78+2 -0	
	150 sq.mm		78+2 -0	
	161 sq.mm		78+3 -0	
	193 sq.mm		78+3 -0	



Cross-section of contact wire Mm ²	DIMENSION (mm)						DIMENSION IN DEGREES		
	A	B	C	D	E	F	L	M	N
107	12.24 \pm 0.16	-	-	6.92 \pm 0.15	6.50	4.43	27 \pm 1 -0	51 \pm 1 -0	78 \pm 2 -0
150	14.50 \pm 0.20	-	-	6.92 \pm 0.15	6.50	4.00	27 \pm 1 -0	51 \pm 1 -0	78 \pm 2 -0
161	15.00 \pm 0.15	12.2	12.00 \pm 0.25	8.50 \pm 0.18 - 0.30	8.10	5.75	27 \pm 2 -0	51 \pm 1 -0	78 \pm 3 -0
193	16.4 \pm 0.15	12.2	12.00 \pm 0.25	8.50 \pm 0.18 - 0.30	8.10	5.3	27 \pm 2 -0	51 \pm 1 -0	78 \pm 3 -0

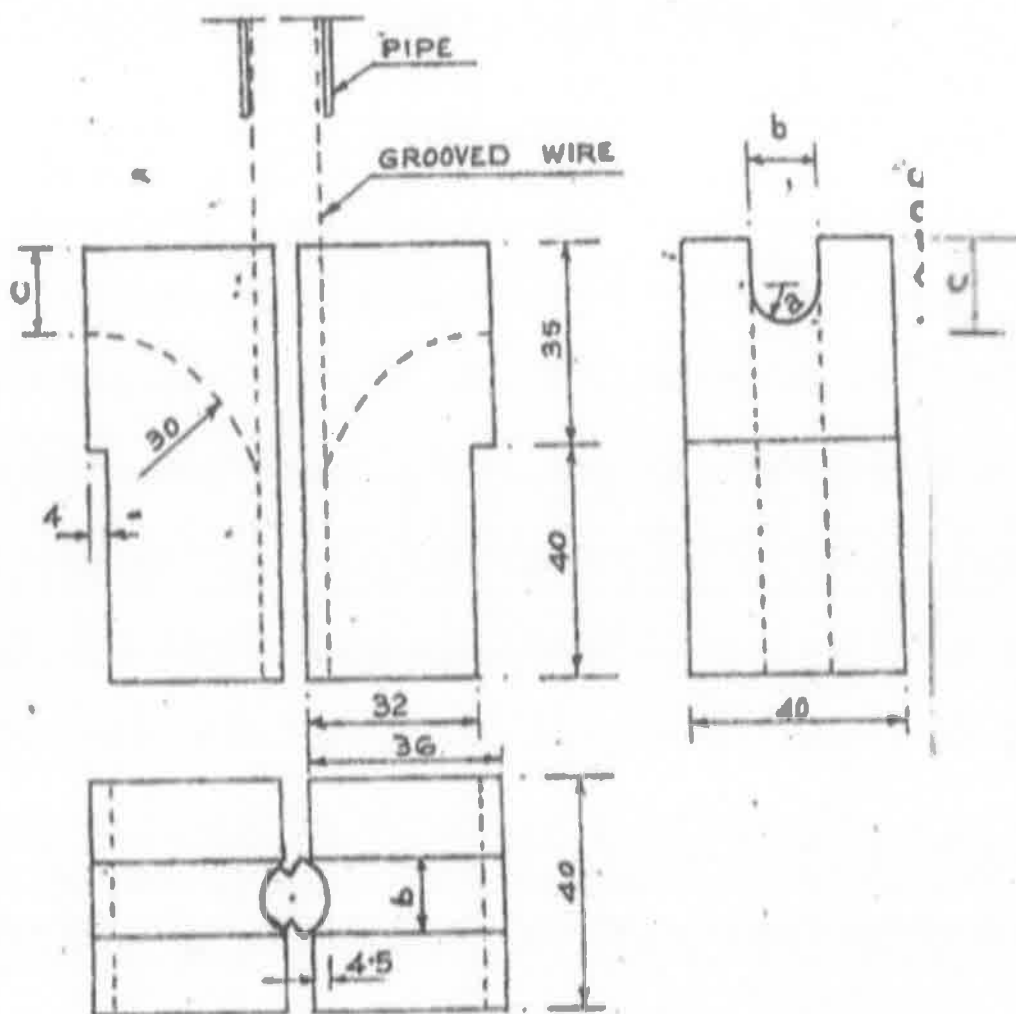
FIG 1 CONFIGURATION OF CONTACT WIRE



SIZE OF WIRE (mm ²)	VALUE OF ALPHA (DEGREE)	VALUE OF BETA (DEGREE)	VALUE IN	
			E ₁ (mm)	E ₂ (mm)
107	51	27	0.9	0.9
150	51	27	0.9	0.9
161	51	27	1.1	1.8
193	51	27	1.1	1.8

NOTE : THE TOLERANCE ON THE MEASUREMENT OF ANGLES IS ± 5 MINUTES

FIG 2 : SPECIAL CALIPER FOR CHECKING CONTACT WIRE



NOTE : ALL DIMENSIONS ARE IN mm.

SIZE OF WIRE (mm ²)	a (mm)	b (mm)	c (mm)
107	6.5	13	15
150	7.65	15.3	18
161	7.9	15.8	18
193	8.5	17	18

FIG 3 : JAWS FOR BENDING TESTS