
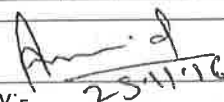
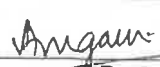


A & C Slip No.-09

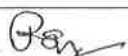
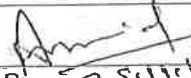
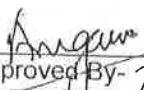
Reason for Amendment: To address the issue of short length being supplied by some manufacturer

Date of Issue: November 2016

Sl. No.	Clause No.	Existing Provisions	As amended
1.	<u>2.1</u>	<p>In the preparation of this specification assistance has been taken from the following standards and specifications.</p> <p>2.1.1 IS:191 (Pt.V)-1980 Specification for copper.</p> <p>2.1.2 IS: 1778 -1980 Specification for Reels and drums for bare conductors.</p> <p>2.1.3 IS: 1885 (Pt.xxxii)-1971 - Glossary of terms for electrical cables and conductors.</p> <p>2.1.4 IS : 9713 -1983 -Specification for hot rolled electrolytic copper wire rods for electrical conductors.</p> <p>2.1.5 IS:440-1964 - Methods of chemical analysis of copper.</p> <p>2.1.6 IS : 191 (Pt.III)-1980 - Specification for copper.</p>	<p>In the preparation of this specification assistance has been taken from the following standards and specifications.</p> <p>2.1.1 IS:191 (Pt.V)-1980 Specification for copper.</p> <p>2.1.2 IS: 1778 -1980 Specification for Reels and drums for bare conductors.</p> <p>2.1.3 IS: 1885 (Pt.xxxii)-1971 - Glossary of terms for electrical cables and conductors.</p> <p>2.1.4 IS : 9713 -1983 -Specification for hot rolled electrolytic copper wire rods for electrical conductors.</p> <p>2.1.5 IS:440-1964 - Methods of chemical analysis of copper.</p> <p>2.1.6 IS : 191 (Pt.III)-1980 - Specification for copper.</p> <p>2.1.7 NEMA WC 26-2008 : Binational Wire and Cable Packaging Standard.</p>
2.	<u>10.3.1</u>	<p>The contact wire shall be supplied properly wound on wooden drums 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. A drum shall carry only one continuous length of contact wire. The plastic sheet covering over the last layer of the contact wire shall be provided to avoid any damage to contact wire, loss/damage due to entanglement of wire, if any, will be to suppliers account.</p>	<p>(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.</p> <p>(ii) A drum shall carry only one continuous length of contact wire.</p> <p>(iii) In order to avoid any damage to Contact Wire, corrugated paper sheet of</p>

Signature			
Name & Designation	Prepared By: SSE/TI	Checked By: Dy. Director-TI-II	Approved By: 29.11.16 ED/TI

		<p>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.</p> <p>(iv) Inner side of flanges shall also be provided with corrugated paper sheet of Min. 3.00 mm thickness pasted/tied to flange.</p> <p>(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.</p> <p>(vi) Any damage in the Contact Wire shall be to supplier's account.</p>									
3.	<u>10.3.5</u>	<p>The drum shall comply with IS: 1778-1980 "Specification for Reels and Drums for bare conductors". The drum on which the contact wire is wound shall have the dimensions as indicated in TABLE-4.</p> <p>(i) The wooden drum shall comply with IS: 1778-1980 "Specification for Reels and Drums for bare conductors" and shall have the dimensions as indicated in TABLE-4.</p> <p>(ii) Corrugated Steel drums shall be of maximum capacity 3570 Kg as per Table 2.2 type RM of NEMA WC 26-2008. Size of the selected drum for 107 mm² HDGC Contact Wire is as per table below:</p> <table border="1"> <tr> <th>Flange</th> <th>Barrel Dia</th> <th>Traverse</th> </tr> <tr> <td>72 inch</td> <td>48 inch</td> <td>36 inch</td> </tr> <tr> <td>1828.8 mm</td> <td>1219.2 mm</td> <td>914.4 mm</td> </tr> </table> <p>(iii) Gross Weight of Steel Drum specified in Para (ii) above, after winding contact wire shall be limited to 2800 kg.</p>	Flange	Barrel Dia	Traverse	72 inch	48 inch	36 inch	1828.8 mm	1219.2 mm	914.4 mm
Flange	Barrel Dia	Traverse									
72 inch	48 inch	36 inch									
1828.8 mm	1219.2 mm	914.4 mm									

Signature			
Name & Designation	Prepared By:- SSE/II	Checked By:- Dy. Director-TI-II	Approved By:- ED/TI

Page No. 1 of 1	Addendum & Corrigendum Slip No. 08 to RDSO's Technical Specification No. ETI/OHE/76 (6/97) (with A & C Slip No. 1, 3, 4, 5, 6 & 7) for Hard Drawn Grooved Copper Contact (HDGC) Wire for Overhead Electric Traction drawn out of CCC Wire Rods (South Wire Process).
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A & C Slip No.08

Reason for Revision : In Compliance to Vigilance Cell note no. 13/Vig/Policy, dated 26.07.2016 & 08.09.2016.

Date of Issue : 28.09.2016

Clause No. 12 to be added as under:

"All the Provisions contained in RDSO's ISO procedures laid down in document No. QO-D-7.1-11, dated 19.07.2016 (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 products supplied to Railways."

Angam
ED (TI) 28-9-16

~~EDTI (Cord.)~~

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28/9
(Sr ED/TI)

Page No. 1 of 1	Addendum & Corrigendum Slip No.07 to RDSO's Technical Specification No. ETI/OHE/76 (6/97) (with A & C Slip No.1, 3, 4, 5 & 6) for Hard Drawn Grooved Copper Contact (HDGC) Wire for Overhead Electric Traction drawn out of CCC Wire Rods (South Wire Process).
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A & C Slip No.07

Reason for Revision : To overcome from the difficulty in availability of 25.5 mm to 26.5 mm diameter Continuous Cast Copper Wire Rod of Southwire Process to be used in manufacturing of 193 mm² HDGC Contact Wire.

Date of Issue : 09.12.2013.

Table 3 of the A & C Slip No. 04 to RDSO's Technical Specification No. ETI/OHE/76(6/97) with A & C Slip No.1, 3, 4, 5 & 6 [for Hard Drawn Grooved Copper Contact (HDGC) Wire for Overhead Electric Traction drawn out of CCC Wire Rods (South Wire Process)] shall be read as under:

Table-3

PROPERTIES OF HARD DRAWN GROOVED COPPER CONTACT WIRE

Cross Section	Diameter of CCC Wire Rod		Standard Weight/Km	Resistance/Km at 20° C	Tensile Strength	Conventional Limit of Elasticity	Elongation in 200 mm	No. of Bending	Hardness
1	2		3	4	5	6	7	8	9
Nominal	Min.	Max.	Nominal	Nominal	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	0.1650	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 Columns 3 & 4 correspond to Nominal Cross-Sectional Area of HDGC Contact Wire

(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). Para 9.6.1.1 (a) ---Additional Para to above Specification.

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

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[Signature]
S. R. G. (TI)

[Signature]
9.12.2013

Page No. 1 of 2	Addendum & Corrigendum Slip No.06 to RDSO's Technical Specification No. ETI/OHE/76(6/97) with A & C Slip No.1, 3, 4 & 5 for Hard Drawn Grooved Copper Contact (HDGC) Wire for Overhead Electric Traction drawn out of CCC Wire Rods (South Wire Process).
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A & C Slip No.6

Reason for Revision

For provision of Indigenous CCC Wire Rods for manufacturing of HDGC Contact Wires, standardisation of Oxygen content and verification of import of CCC Wire Rods

Date of Issue

09.05.2012.

SN	Para No.	Existing provisions	As amended																																																								
1.	Para 4.1 (A&C No. 5)	The HDGC Contact Wire shall be drawn out of imported CCC Wire Rods, manufactured by South Wire Process, of diameter as given in Table-3 of A & C Slip No. 4. It will continue till such time Contact Wire manufactured from indigenous CCC Wire Rod is cleared for regular use after monitoring of their field performance. The composition of the Copper shall be as given in Table-2	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 of A & C Slip No. 4. The composition of the Copper shall be as given in Table-2. The manufacturer of CCC Wire Rod which is used in the manufacture of prototype Contact Wire will be treated as approved Vendor for CCC Wire Rod once the prototype Contact Wire manufactured by this CCC Wire Rod is approved.																																																								
2.	Para 4.1	TABLE – 2 CHEMICAL COMPOSITION OF COPPER	TABLE – 2 CHEMICAL COMPOSITION OF COPPER																																																								
		<table><tr><td>Element</td><td>% ppm</td></tr><tr><td>Cu+Ag</td><td>99.95%min</td></tr><tr><td>Bi</td><td><2 ppm</td></tr><tr><td>Te</td><td><2 ppm</td></tr><tr><td>Se</td><td><2 ppm</td></tr><tr><td>Bi+Te+Se</td><td><3 ppm</td></tr><tr><td>Pb</td><td><5 ppm</td></tr><tr><td>Sb</td><td><4 ppm</td></tr><tr><td>As</td><td><5 ppm</td></tr><tr><td>Fe</td><td><10 ppm</td></tr><tr><td>S</td><td><15pm</td></tr><tr><td>Sn+Ni+Fe+Si+Zn+Co</td><td><20 ppm</td></tr><tr><td>Cr+Mn+Sb+Cd+As+P</td><td><15ppm</td></tr><tr><td>Oxygen</td><td><300</td></tr></table>	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	<15pm	Sn+Ni+Fe+Si+Zn+Co	<20 ppm	Cr+Mn+Sb+Cd+As+P	<15ppm	Oxygen	<300	<table><tr><td>Element</td><td>% ppm</td></tr><tr><td>Cu+Ag</td><td>99.95% min</td></tr><tr><td>Bi</td><td><2 ppm</td></tr><tr><td>Te</td><td><2 ppm</td></tr><tr><td>Se</td><td><2 ppm</td></tr><tr><td>Bi+Te+Se</td><td><3 ppm</td></tr><tr><td>Pb</td><td><5 ppm</td></tr><tr><td>Sb</td><td><4 ppm</td></tr><tr><td>As</td><td><5 ppm</td></tr><tr><td>Fe</td><td><10 ppm</td></tr><tr><td>S</td><td><15pm</td></tr><tr><td>Sn+Ni+Fe+Si+Zn+Co</td><td><20 ppm</td></tr><tr><td>Cr+Mn+Sb+Cd+As+P</td><td><15ppm</td></tr><tr><td>Oxygen</td><td>200 to 350</td></tr></table>	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	<15pm	Sn+Ni+Fe+Si+Zn+Co	<20 ppm	Cr+Mn+Sb+Cd+As+P	<15ppm	Oxygen	200 to 350
Element	% ppm																																																										
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Bi+Te+Se	<3 ppm																																																										
Pb	<5 ppm																																																										
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Cr+Mn+Sb+Cd+As+P	<15ppm																																																										
Oxygen	200 to 350																																																										

Page No. 2 of 2	Addendum & Corrigendum Slip No.06 to RDSO's Technical Specification No. ETI/OHE/76(6/97) with A & C Slip No.1, 3, 4 & 5 for Hard Drawn Grooved Copper Contact (HDGC) Wire for Overhead Electric Traction drawn out of CCC Wire Rods (South Wire Process).
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3.	Para 8.5.8	Nil	Supplier shall be required to submit following Documents at the time of Routine Inspection which shall be part of Inspection Certificate. I. Proof of purchase of CCC Wire Rod from the approved Vendor. II. For imported CCC Wire Rod the Supplier shall submit proof of import i.e. i. Bill of Entry. ii. Bill of Lading. 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.
4	Para 9.3	ROUTINE TESTS	ROUTINE TESTS
	9.3.1	Visual Examination	Visual Examination
	9.3.2	Verification of dimensions	Verification of dimensions
	9.3.3	Measurement of weight	Measurement of weight
	9.3.4	Tensile test	Tensile test
	9.3.5	Elongation test	Elongation test
	9.3.6	Bending test	Bending test
	9.3.7	-	Oxygen Content
5.	Para 10.2 (iii)	Lot Number	Lot Number and written submission of declaration from the manufacturer regarding use of CCC Wire Rod from approved source with proof of purchase along with relevant Documents.


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Page no.1 of 1	A&C Slip No.5 to Specification No. ETI/OHE/76(6/97) for Hard Drawn Grooved Copper Contact wire for overhead electric traction drawn out of CCC wire rods.
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SN	Para No.	Existing entries	As amended
1	4.1	The HDGC contact wire shall be made from CCC wire rods of diameter 21 mm or above, manufactured by South Wire Process. The composition of the copper shall be as given in TABLE-2	The HDGC contact wire shall be drawn out of imported CCC wire rods manufactured by South Wire Process of diameter as given in Table-3 of A&C Slip no.4. It will continue till such time contact wire manufactured from indigenous CCC wire rod is cleared for regular use after monitoring of their field performance. The composition of the copper shall be as given in Table-2.

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Page no.1 of 1	A&C Slip no.4 to specification No. ET/OHE/76(6/97) for hard drawn grooved copper contact wire for overhead electric traction drawn out of CCC wire rods.
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Clause 6.2: The Table-3 and note-1 of Clause 6.2 of Addendum & Corrigendum Slip No.3 shall be replaced with the following.

TABLE – 3

PROPERTIES OF HARD DRAWN GROOVED 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 200mm	Nos of bending	Hardness
1	2		3	4	5	6	7	8	9
Nom	min	max	Nom.	Nom.	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	23.5	26.5	1431.3	0.1103	36.5	31.0	3	6	107
193	25.5	26.5	1715.8	0.0921	36.5	31.0	3	5	107

Note –1: shall be read as under:-

“Values given in column-3&4 corresponds to nominal cross sectional area of contact wire.”

(December 2006)

Page No. 1 of 2	A& C Slip no. 3 to Specification No. ETI/OHE/76(6/97) for Hard Drawn Grooved Copper Contact wire for overhead electric traction drawn out of CCC wire rods
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CLAUSE 6.0 SIZES, SHAPES, DIMENSIONS, WEIGHTS AND OTHER PROPERTIES OF CONTACT WIRE

Clause 6.2 : The Table of clause 6.2 of Addendum & Corrigendum slip no. 1 shall be replaced with the following:

TABLE-3
PROPERTIES OF HARD DRAWN COPPER CONTACT WIRE

Cross Section	Dia of CCC rod		Standard weight per km	Resistance/ km at 20°C	Tensile Strength	Conventional limit of elasticity	Elongation in 200mm	nos. of bends	Hardness
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)
nom	min.	max.	nom	nom	min.	min.	min.	min.	min.
mm ²	mm	mm	Kg	ohms	Kgf/mm ²	Kgf/mm ²	%	Nos.	BHN
107	19.6	21	951.2	0.1660	36.5	31.0	3	7	107
150	23	25	1333.5	0.1184	36.5	31.0	3	6	107
161	24	26	1431.3	0.1103	36.5	31.0	3	6	107
193	26	-	1715.8	0.0921	36.5	31.0	3	5	107

Note -1 shall be read as under:

Note-1: Tolerance on diameters of CCC wire rod shall be within $\pm 0.5\text{mm}$. Values given in column-3 & column-4 correspond to nominal cross sectional area of contact wire.

CLAUSE 8.0 TESTS ON CCC WIRE RODS

Add an additional test at clause 8.1.1:

(viii) Electrical Resistivity Test

CLAUSE 8.2 ACCEPTANCE TESTS

Clause 8.2.1 shall be renumbered as Clause 8.2.2 and shall be replaced with the following.

Clause 8.2.2

The following tests shall be carried out in accordance with ETI/OHE/65(8/87) on the samples of CCC wire rods drawn in accordance with IS:9713-1983(for the purpose of sampling).

Page No. 2 of 2	A & C Slip no. 3 to Specification No. ETL/OHE/76(6/97) for Hard Drawn Grooved Copper Contact wire for overhead electric traction drawn out of CCC wire rods
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- (i) Visual inspection
- (ii) Verification of dimensions
- (iii) Compression test
- (iv) Tensile strength/elongation test
- (v) Chemical composition
- (vi) Electrical Resistivity Test

Clause 8.2.1 shall be read as under:

“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.

CLAUSE 9.6 : SELECTION OF SAMPLES FOR TESTS & CRITERIA OF APPROVAL

Add new clause 9.6.3.9

Acceptance of the records maintained for tests in accordance with 8.5.7 will form a part of the acceptance tests for the contact wire.

Clause 10.3: PACKING AND MARKING OF CONTACT WIRE

Clause 10.3.9 shall be read as under:

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 & net weight
- v) Drum number
- vi) Consignee and other particulars as required by the purchaser.
- vii) Make, batch no. and month & year of procurement of CCC wire rod .

Page No. 1 of 2	A & C Slip No.1 to Specification No.ETI/OHE/76(6/97) for Hard Drawn Grooved Copper Contact wire for overhead electric traction drawn out of CCC wire rods
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Clause 4.0 MATERIAL

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Clause 4.1 shall be read as under :

"The HDGC contact wire shall be made from CCC wire rods, manufactured by South wire Process. The composition of the copper shall be as given in Table-2 (Table 2 will be read as given in the Specification)".

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

Clause 6.2 The Table of clause 6.2 shall be replaced with the following :

TABLE - 3
PROPERTIES OF HARD DRAWN COPPER CONTACT WIRE

Cross Sectional Area	Min. Diameter of CCC Rod	Standard weight per km	Max. resistance per km at 20° C	Min. Tensile strength	Conventional limit of elasticity	Min. Elongation in 200 mm	Min. nos. of bending	Hardness Brinnell scale.
mm ²	mm. or above	Kg	Ohms	Kg/mm ²	Kg/mm ²	%	Nos.	BHN
107	21	951.2	0.1699	36.5	31.0	3	7	107 (min.)
150	23	1333.5	0.1212	36.5	31.0	3	6	107 (min.)
161	26	1431.3	0.1125	36.5	31.0	3	6	107 (min.)
193	26	1715.8	0.0936	36.5	31.0	3	5	107 (min.)

Clause 8.5.2 MEASUREMENT OF DIMENSIONS

The last sentence of this para shall be replaced as under.

"The diameter shall be as per Column 2 of Table 3 of clause 6.2".

Clause 8.5.4 TENSILE STRENGTH/ELONGATION TEST.

This clause shall be replaced by the following :

When tested in accordance with IS : 1608 – 1995 or latest "Mechanical Testing of Metals" 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.

Page No. 2 of 2	A & C Slip No.1 to Specification No.ETI/OHE/76(6/97) for Hard Drawn Grooved Copper Contact wire for overhead electric traction drawn out of CCC wire rods
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Clause 9.5.9 HARDNESS TEST

This clause shall be replaced by the following :-

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 : 1500-1983.

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.

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Dated. 09.04.2001

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ET/OHE/76(6/97)

SPECIFICATION NO.ET/OHE/76(6/97)

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

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

Issued by
RESEARCH DESIGNS & STANDARDS ORGANISATION
MANAK NAGAR, LUCKNOW 226 011 (INDIA)

(For official use only)

725 C.

**SPECIFICATION FOR HARD DRAWN GROOVED 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 made from continuous cast copper (CCC) wire rods for electric traction overhead lines.

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 (Pt.V)-1980 | - | Specification for copper. |
| 2.1.2 | IS:1778-1980 | - | Specification for Reels and drums for bare conductors. |
| 2.1.3 | IS:1885(Pt.xxxii)-1971 | - | Glossary of terms for electrical cables and conductors |
| 2.1.4 | IS:9713-1983 | - | Specification for hot rolled electrolytic copper wire rods for electrical conductors. |
| 2.1.5 | IS:440-1964 | - | Methods of chemical analysis of copper. |
| 2.1.6 | IS:191(Pt.III)-1980 | - | Specification for copper. |

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 tenderer 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 tenderer.

2.4 For the purpose of this specification, the definitions given in IS:1885 (Part-xxxii) - 1971 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

i)	Maximum ambient air temperature	50° C
ii)	Average ambient air temperature over a period of 24 hours	35° C
iii)	Maximum relative humidity	100%
iv)	Annual 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
iii)	Basic wind pressure	200 kgf/m ²
ix)	Altitude	Not exceeding 1000 m

4.0 MATERIAL

4.1 The HDGC contact wire shall be made from CCC wire rods of diameter 21mm or above, manufactured by Southwire Process. The composition of the copper shall be as given in TABLE-2.

TABLE - 2
CHEMICAL COMPOSITION OF COPPER

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	<300 ppm

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 has been adopted in calculating the resistances specified in IS:3476-1967.

$$P = T/16$$

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 $1/58 = 0.017241 \text{ ohm mm}^2/\text{m}$.

5.1.1.3 Copper which has a resistivity at 20°C of $1/58 = 0.017241 \text{ ohm mm}^2/\text{m}$ 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 for 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. The figures therein shall be subject to a tolerance of +/- 3%, except weights. Tolerances on weight shall be +/- 3.0% in case of 107mm² and 150 mm² contact wire and +/- 2.0% in case of 161mm² & 193mm² contact wire.

TABLE - 3
PROPERTIES OF HARD DRAWN COPPER CONTACT WIRE

cross-sectional area	Standard weight per km	Max. resistance per km at 20°C	Min tensile strength	Conventional limit of elasticity	Min. elongation in 200mm	Min. no. of bending	Hardness Brinell Scale
mm ²	kg	ohm	kg/mm ²	kg/mm ²	%		
107	951.2	0.1699	36.5	31.0	3	7	105(min)
150	1333.5	0.1212	36.5	31.0	3	6	105(min)
161	1431.3	0.1125	33.0	-	3	6	under consideration
193	1715.8	0.0936	31.0	-	4	5	

Note- 1: The values given in column-2 correspond to the nominal cross-sectional area of contact wire. The values given in column 3 correspond to minimum cross-sectional area of the contact wire.

Note- 2: 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 be not 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 km 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 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 other 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 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 contact 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 (IT)/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 (IT)/RDSO shall be carried out expeditiously by the manufacturer.

7.3 Type-testing Schedule :- Prior to giving a call to the Director General (IT)/RDSO for inspection and testing of the prototype, the manufacturer shall submit a detailed test schedule consisting of schematic circuit diagrams 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 tests 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 the 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 (IT)/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 (IT)/RDSO as the case may be, 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 reason attributable to the manufacturer and it is required for the representative of the Director General (IT)/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 (IT)/RDSO the costs 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(IT)/RDSO to the manufacturer, shall he 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

The tenderer shall furnish alongwith 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(Pt.III)-1980.

- i) Visual Examination.
- ii) Measurement of dimensions.
- iii) Compression test.

- iv) Tensile strength/elongation test.
- v) Chemical composition.
- vi) Micro-structure examination.
- vii) Ultrasonic / eddy current testing at the time of wire drawing.

8.2 ACCEPTANCE TESTS

8.2.1 The following tests shall be carried out on the samples of CCC wire rods drawn in accordance with IS:9713-1983.

- i) Visual Examination.
- ii) Measurement of dimensions.
- iii) Compression test.
- iv) Tensile strength / elongation test.
- v) Chemical composition.

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, indentations, 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. A lot shall be as stipulated in IS:9713-1983.

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:191 (Pt.III)-1980.

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.

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 21 mm or above.

8.5.3 COMPRESSION TEST

A sample of length twice the diameter of the CCC wire 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:2654-1977, "Method for tensile testing of copper and alloy" for tensile strength and elongation, the material shall have a tensile strength of 20.4 kg/mm² (min.) and a minimum of 46% elongation on a gauge length of 250mm.

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. For oxygen content, certificate from the manufacturer of copper shall be furnished.

8.5.6 MICRO-STRUCTURE EXAMINATION

The sample of CCC wire rod cut along transverse sections polished and etched shall show equiaxed recrystallised 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 The CCC wire rod shall be either ultrasonically or through eddy current method tested by the manufacturer continuously during production of contact wire for the entire length. The defect if any, observed shall require that portion of the rod to be removed. Records shall be maintained for the purpose and produced before the inspector on demand.

9.0 TESTS ON CONTACT WIRE

9.1 TYPE TESTS

The CCC wire 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

9.2 ACCEPTANCE TESTS

Same as type tests except that indicated in Clause 9.1.10. In addition weight of 3 or 1/5th of offered contact wire drums for acceptance tests, whichever is higher, for gross weight. The Inspector shall verify the results of manufacturer's tests.

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

9.4 MANUFACTURER'S TESTS

9.4.1 The manufacturer shall test every lot of CCC wire rods for chemical composition. A lot shall be as stipulated in IS:9713-1983. 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 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.

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.

9.5.5 MEASUREMENT OF WEIGHT

The weight of the contact wire, per km shall be calculated by weighing a piece of 50 m length by a balance of accuracy of ± 1 gm, preferably by a digital balance.

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 250 mm shall be taken. A gauge length of 200 mm shall be marked on the test piece for the purpose of measuring the elongation. If the sample contains a joint, it shall be in the middle

of the gauge length. 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 out side 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.

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 operations 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.

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:1790-1961.

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.

9.6 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.

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

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

9.6.3.6 Tensile and elongation tests.

9.6.3.7 Bending test.

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

9.6.4 Should a sample of contact wire fail in any one of the tests, 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 subjected 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 WIRE 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;
- 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 The contact wire shall be supplied properly wound on drums, in specified lengths as required by the purchaser, the turns of the wire being close and continuous without any over-riding except on the first and last turns of each layer. A drum shall carry only one continuous length of contact wire. The plastic sheet covering over the last layer of the contact wire shall be provided to avoid any damage to contact wire, loss/damage due to entanglement of wire, if any, will be to suppliers 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 that 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 the value specified by the purchaser.

10.3.5 The drum shall comply with IS:1788-1980 "Specification for Reels and Drums for bare conductors". The drum on which the contact wire is wound 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 of* contact wire (m)	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 be exceeded by more than 50m.

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

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 from top lobe to bottom 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 manufacturer in 3mm 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 such that it is not detrimental to the strength of the contact wire.

10.3.8 The letter 'cc' shall be provided alongwith emblem/identification mark.

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

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:

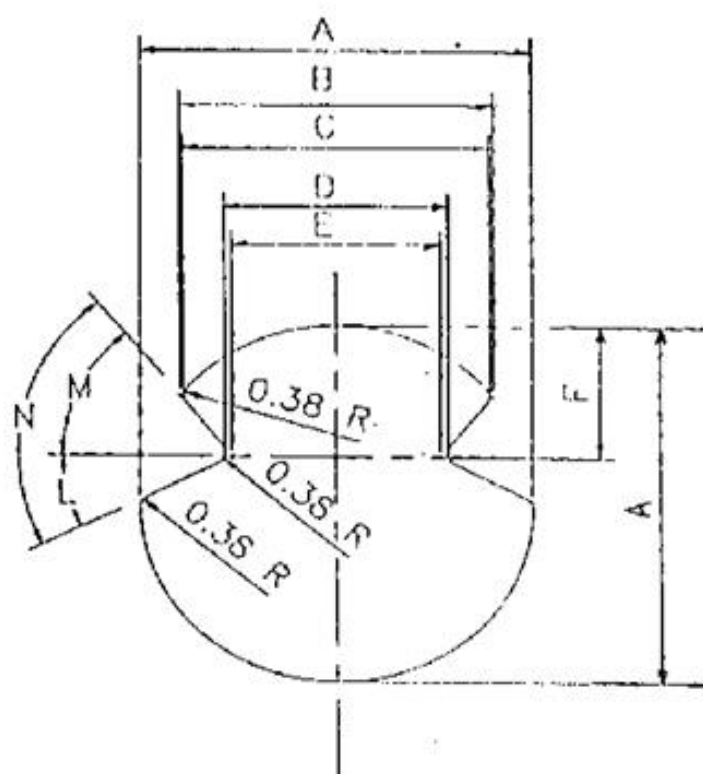
TEMPERATURE °C	MULTIPLIER CONSTANT	RECIPROCAL OF CONSTANT
5.0	1.0606	0.9429
5.5	1.0585	0.9448
6.0	1.0563	0.9467
6.5	1.0542	0.9486
7.0	1.0521	0.9505
7.5	1.0500	0.9524
8.0	1.0479	0.9543
8.5	1.0458	0.9562
9.0	1.0437	0.9581
9.5	1.0417	0.9600
10.0	1.0396	0.9624
10.5	1.0376	0.9638
11.0	1.0355	0.9657
11.5	1.0335	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	0.9944
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 $T^{\circ}\text{C}$ is measured, the resistance at 20°C is obtained by multiplying the resistance at $T^{\circ}\text{C}$ by the multiplying constant against the value of $T^{\circ}\text{C}$ given in column 2. If the resistance at 20°C is known, the resistance at $T^{\circ}\text{C}$ is obtained by multiplying the resistance at 20°C by reciprocal indicated against $T^{\circ}\text{C}$ 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 0.003 81 per $^{\circ}\text{C}$ at 20°C which is an average value for copper of 97% conductivity. The error in using this table for copper in the range of conductivity of 96% to 98% will not exceed 0.06%.

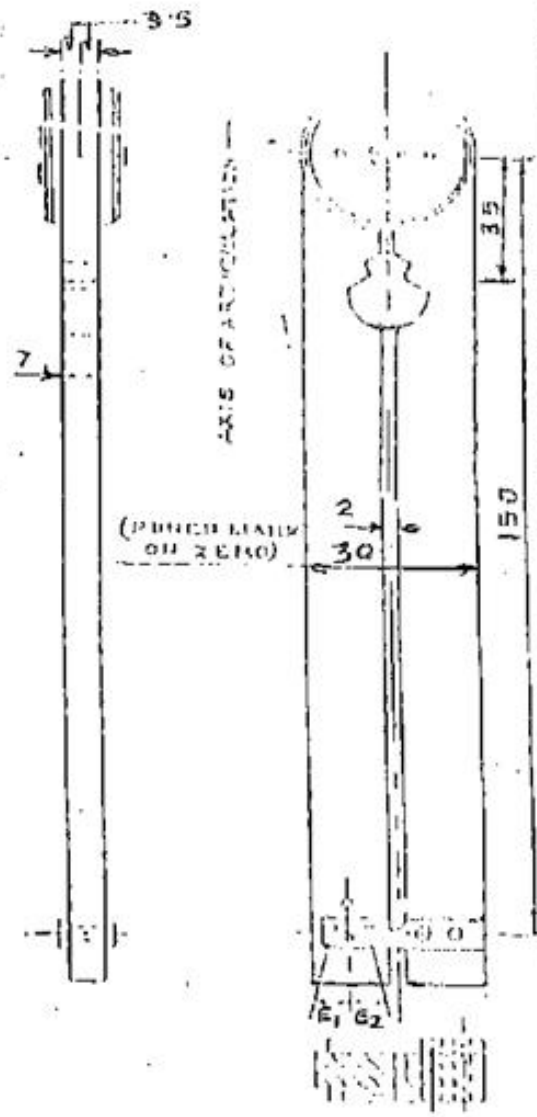
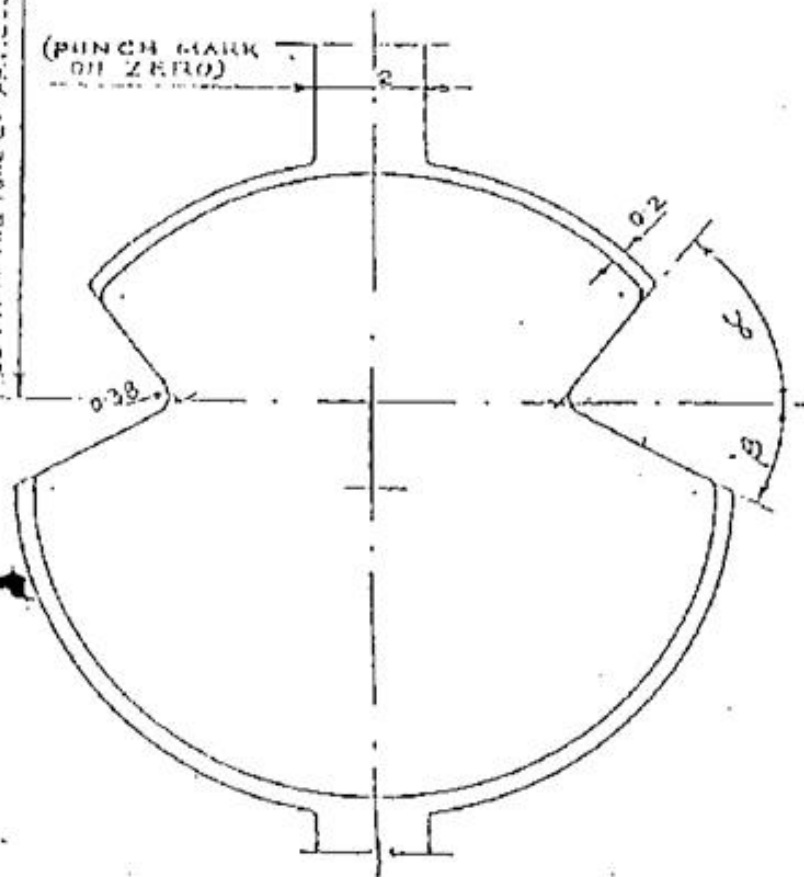
XXXXXXXXXXXX



CROSS-SECTION OF CONTACT WIRE (mm ²)	DIMENSION (mm)						DIMENSION IN DEGREES		
	A	B	C	D	E	F	L	M	N
107	12.24±0.10	-	-	6.92±0.15	6.50	4.43	27 ⁺¹ ₋₀	51 ⁺¹ ₋₀	78 ⁺² ₋₀
150	14.50±0.20	-	-	6.92±0.15	6.50	4.00	27 ⁺¹ ₋₀	51 ⁺¹ ₋₀	78 ⁺² ₋₀
161	15.00±0.15	12.2	12.00±0.25	8.00 ^{+0.18} _{-0.30}	8.10	6.75	27 ⁺² ₋₀	51 ⁺¹ ₋₀	78 ⁺³ ₋₀
193	16.4±0.15	12.2	12.00±0.25	8.50 ^{+0.18} _{-0.30}	8.10	5.3	27 ⁺² ₋₀	51 ⁺¹ ₋₀	78 ⁺³ ₋₀

FIG.1 CONFIGURATION OF CONTACT WIRE

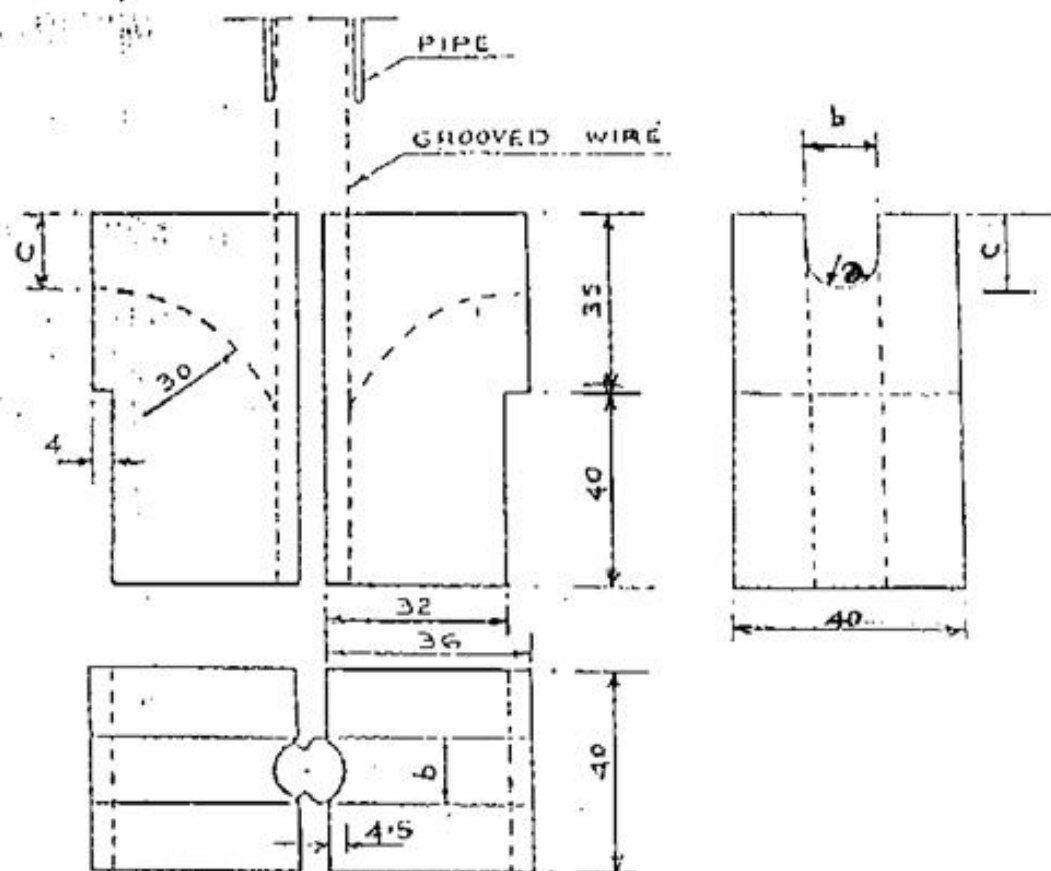
25 FROM THE AXIS OF ARTICULATION



SIZE OF WIRE (mm ²)	VALUE OF α (DEGREE)	VALUE OF β (DEGREE)	VALUE IN	
			E1 (mm)	E2 (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.

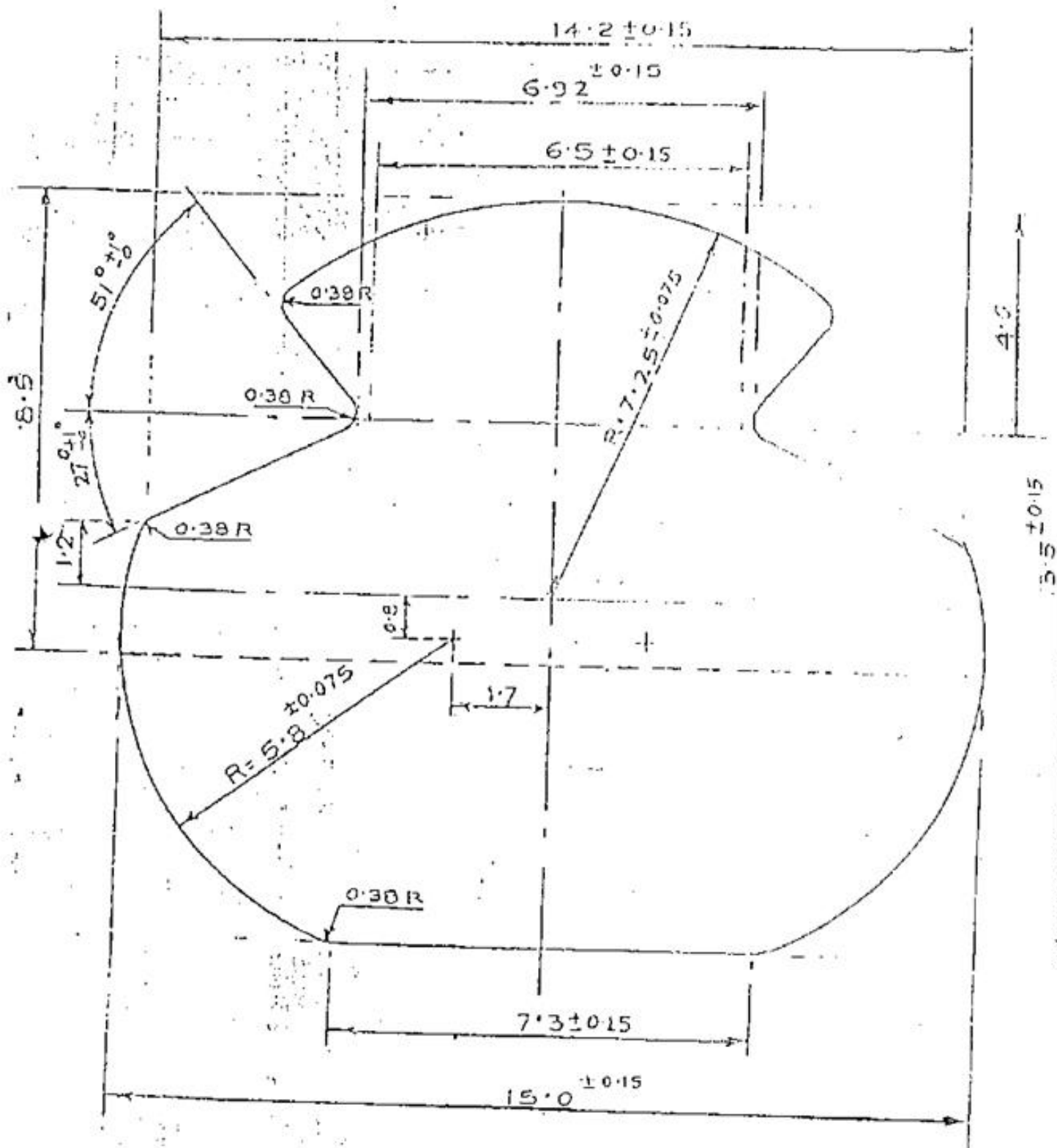
FIG.2 SPECIAL CALIPER FOR CHECKING CONTACT WIRE



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	15.0	18
192	8.5	17	18

FIG. 3 JAWS FOR
BENDING TESTS



PROFILE OF GROOVED CONTACT WIRE (150 mm^2)
(FLAT BOTTOM)

FIG. 4

ETI/OHE/76 (6/97)