इंटरनेट मानक

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Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

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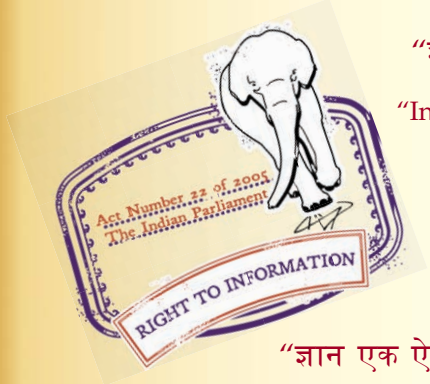
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 191 (2007): Copper [MTD 8: Copper and Copper Alloys]



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Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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भारतीय मानक

ताँबा — विशिष्टि

(चौथा पुनरीक्षण)

Indian Standard

COPPER — SPECIFICATION

(Fourth Revision)

ICS 77.150.30

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 2007

Price Group 5

FOREWORD

This Indian Standard (Fourth Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Copper and Copper Alloys Sectional Committee had been approved by the Metallurgical Engineering Division Council.

The second revision of this standard was published in 1967, which was subsequently revised in 1980. The Committee responsible for the formulation of this standard felt that different types of copper included in the earlier version of the standard should be reviewed and merged in line with International/Overseas Standards. In the formulation of this standard, consideration has been given to the manufacturing and trade practices followed in the country. While revising IS 191 it was decided to merge all the following ten parts:

Part I	Classification of copper
Part II	Dimensions and masses of copper refinery shapes
Part III	Methods of sampling of copper refinery shapes for chemical analysis
Part IV	Cathode copper
Part V	Electrolytic tough pitch copper (ETP)
Part VI	Fire refined high conductivity copper (FRHC)
Part VII	Fire refined tough pitch copper — wrought products and alloys (FRTP 1 and FRTP 2)
Part VIII	Phosphorized copper (DHP)
Part IX	Arsenical tough pitch copper (ATP)
Part X	Phosphorus deoxidized arsenical copper (DPA)

In this revision, the following modifications have been made:

a) ISO designations have been adopted;
b) High purity grade Cu-CATH-1 has been added;
c) Co-relation of old designations with new designations has been given for information (*see* Annex A);
d) A new clause on references has been incorporated;
e) New terms have been added;
f) Tolerances on mass and dimensions of various refinery shapes have been given in tabular form;
g) Chemical composition have been given in the tabular form;
h) Limits of oxygen content have been reduced in some of the grades;
j) Clause on sampling and criteria for conformity has been modified; and
k) Information on electrical resistivity and conductivity relationship added.

While revising the standard assistance has been derived from the following :

ISO 197-1:1983	Copper and copper alloys — Terms and definitions — Part 1 : Materials
ISO 197-2:1983	Copper and copper alloys — Terms and definitions — Part 2 : Unwrought products (refinery shapes)
ISO 431:1981	Copper refinery shapes
ISO 1190-1:1982	Copper and copper alloys — Code of designation — Part 1 : Designation of materials
IEC 60028 (1925-01)	Resistance for copper
EN 1976 : 1998 E	Cast unwrought copper products
BS 6017 : 1981	Copper refinery shapes

(Continued on third cover)

Indian Standard

COPPER — SPECIFICATION

(Fourth Revision)

1 SCOPE

1.1 This standard specifies the chemical composition and physical properties of various types of copper in the form of refinery shapes.

1.2 The refinery shapes include horizontally, vertically and continuously cast wire bars, cakes, billets and ingots. Wire bars, cakes and billets are intended for fabricating into wrought products, ingots are intended for alloying in wrought and cast copper alloys.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
440 : 1964	Methods of chemical analysis of copper (*revised*)
1387 : 1993	General requirements for the supply of metallurgical materials (*second revision*)
3288	Glossary of terms relating to copper and copper alloys:
(Part 1) : 1986	Materials (*third revision*)
(Part 3) : 1986	Wrought forms
3635 : 1966	Methods of test for resistance of metallic electrical resistance material

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 3288 (Parts 1 and 3) and the following shall apply:

3.2 Cathode Copper — Cathode copper is a unwrought flat product produced by electrorefining/electrowinning. Full size cathode or cathode cut to size may be supplied as agreed upon between the supplier and the purchaser.

3.3 Copper — For the purpose of this classification, those coppers the minimum copper content of which shall be 99.85 percent.

3.4 Casting Copper — Fire refined tough pitch copper, usually cast from melted secondary metal into ingot and ingot bars only and used for making foundry castings.

4 GRADES/DESIGNATIONS

4.1 The grades/designations of copper shall be as given in Table 1.

4.2 Basis of Classification

The different refinery shapes currently produced are shown in Table 1. In each type, the specific coppers are not necessarily available in a complete range of sizes in the forms shown, nor from any one supplier in all forms.

5 DIMENSIONS, MASSES AND TOLERANCES

5.1 Horizontally Cast Wire Bars

Horizontally cast wire bars of various nominal masses shall conform to the appropriate dimensions and tolerances given in Fig. 1 and Table 2.

5.2 Billets

Billets shall be of a cylindrical shape with both ends flat. The mass, diameter and length and the maximum deviation from straightness shall conform to the tolerances given in Table 3.

5.3 Other Shapes

The mass, dimensions and straightness of vertically (either statically or continuously) cast wire bars, vertically and horizontally cast cakes and ingots, shall conform to the tolerances given in Table 3.

5.4 Tolerances for Mass and Dimensions

The tolerances on mass and dimensions for refinery shapes other than horizontally cast wire bars are given in Table 3.

6 SUPPLY OF MATERIAL

General requirements for supply of material shall conform to IS 1387.

7 CHEMICAL COMPOSITION

7.1 The copper of all designations shall conform to requirements of Table 4.

1—107 BIS/ND/07

Table 1 Grade/Designation of Copper and Their Refinery Shapes
(*Clauses* 4.1 and 4.2)

Grades/ Designations	Type of Copper	Form of Refinery Shapes Available from Refiners				
		Wire Bars	Billets	Cakes	Ingots and Ingot Bars	Cathodes
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cu-CATH-1	Electrolytic cathode	—	—	—	—	×
Cu-CATH-2	Electrolytic cathode	—	—	—	—	×
Cu-ETP	Electrolytic tough pitch	×	×	×	×	—
Cu-FRHC	Fire-refined high conductivity	×	×	×	×	—
Cu-FRTP-1	Fire-refined tough pitch	—	×	×	×	—
Cu-FRTP-2						
Cu-DHP	Phospherized, high residual phosphorus	×	×	×	—	—
Cu-ATP	Arsenic, tough pitch	—	×	×	—	—
Cu-DPA	Phosphorized, arsenical	—	×	—	—	—

× Commercially available.

Table 2 Masses and Dimensions of Horizontally Cast Wire Bars
(*Clause* 5.1)

Dimensions	Tolerances	Mass, kg					
		91	102	113	120	125	136
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
L (mm)	± 14 mm	1370	1370	1370	1370	1370	1370
L_1 (mm)	± 6 mm	150	150	150	150	150	150
h (mm)	± 6 mm	90	100	100	110	110	120
h_1 (mm)	± 6 mm	25	25	25	25	25	25
b (mm)	± 6 mm	100	100	110	110	110	110
b_1 (mm)	± 6 mm	90	90	100	100	100	100
R (mm)	± 6 mm	16	16	25	25	25	25
R_1 (mm)	± 6 mm	16	16	16	16	16	16
R_2 (mm)	± 6 mm	40	40	40	40	40	40
α (degree)	± 2°	10	10	10	10	10	10
β (degree)	± 2°	10	10	10	10	10	10
γ (degree)	± 1°	3	3	3	3	3	3

7.2 The chemical composition shall be determined either by the method specified in IS 440 or any other established instrumental/chemical method. In case of dispute the procedure specified in IS 440 for chemical analysis, shall be the referee method. However when the method is not given in IS 440, the referee method shall be as agreed to between the purchaser and the manufacturer. The method for determination of oxygen shall be as agreed to between the supplier and the purchaser.

7.3 Alternatively the test method specified in relevant ISO/IEC Standard may be used.

8 FREEDOM FROM DEFECTS

8.1 Cathodes shall be reasonably free from nodules and all foreign materials, such as copper sulphate, dirt, grease and oil, and shall withstand ordinary handling without breakage.

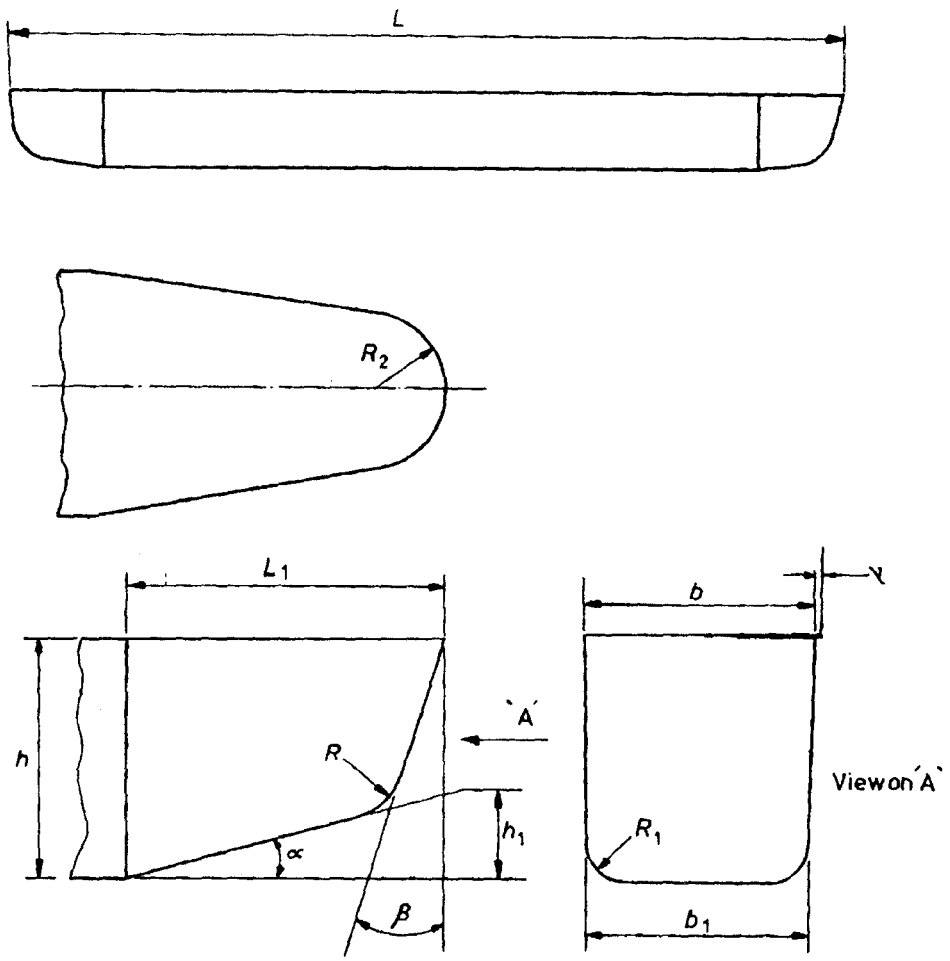

FIG. 1 SHAPE OF HORIZONTALLY CAST WIRE BARS (*SEE* TABLE 4 FOR MASSES AND DIMENSIONS)

Table 3 Tolerances on Mass and Dimensions for Refinery Shapes Other than Horizontally Cast Wire Bars
(*Clauses* 5.2, 5.3 *and* 5.4)

Refinery Shape	Tolerances					
	Mass	Diameter	Length	Width and Thickness	Other Dimensions	Maximum Deviation from Straightness per 1 000 mm Length
	Percent	mm		mm	mm	mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Billets	± 5	± 3	± 2 percent of ordered length	—	—	4
Vertically continuously cast wire bars	± 5	—	—	± 3	± 6	—
Vertically static cast wire bars	± 5	—	—	± 6	± 6	—
Cast cakes width, thickness up to 200 mm	± 5	—	—	± 3	—	4
Cast cakes width, thickness over 200 mm	± 5	—	—	± 6	—	4
Ingots	± 10	—	—	—	—	—

Table 4 Chemical Composition
(Unless otherwise indicated all limits are in percentage)
(*Clause* 7.1)

Designations	Copper + Silver (By Difference), *Min*	Silver, *Max*	Copper (Any Silver Present to be Counted as Copper), *Min*	Phosphorus	Arsenic, *Max*	Antimony, *Max*	Bismuth, *Max*	Iron, *Max*	Lead, *Max*	Nickel, *Max*	Oxygen, *Max*	Selenium, *Max*	Sulphur, *Max*	Tellurium, *Max*	Tin, *Max*	Zinc, *Max*	Selenium + Tellurium, *Max*	Total Impurities, *Max*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
Cu-CATH-1	99.99	25 ppm	—	—	5 ppm	4 ppm	2 ppm	10 ppm	5 ppm	10 ppm	—	2 ppm	15 ppm	2 ppm	—	—	3 ppm (Including bismuth)	65 ppm (Excluding oxygen)
Cu-CATH-2	99.90	—	—	—	—	—	0.001	—	0.005	—	—	—	—	—	—	—	—	0.03
Cu-ETP	99.90	—	—	—	—	—	10 ppm	—	0.005	—	0.045	—	—	—	—	—	—	0.03 (Excluding oxygen and silver)
Cu-FRHC	99.90	—	—	—	—	—	10 ppm	—	0.005	—	0.045	—	—	—	—	—	—	0.03 (Excluding oxygen and silver)
Cu-FRTP-1	—	—	99.85	—	0.02	0.005	0.003	0.010	0.005	0.05	0.10	—	—	—	0.01	—	0.025	0.05
Cu-FRTP-2	—	—	99.50	—	0.10	0.05	0.02	0.03	0.10	0.50	0.10	—	—	—	0.05	—	0.07	—
Cu-DHP	99.80	—	—	0.015 – 0.10	0.05	0.005	0.003	0.03	0.01	0.10	—	—	—	0.01	0.01	—	0.02	0.06 (Excluding silver, nickel, arsenic and phosphorus)
Cu-ATP	99.20	—	—	—	0.20 – 0.50	0.01	0.005	0.02	0.02	0.15	0.10	—	—	—	0.03	—	0.03	—
Cu-DPA	99.20	—	—	0.015– 0.10	0.20– 0.50	0.01	0.003	0.03	0.010	0.15	—	—	—	0.01	0.01	—	0.02	0.06 (Excluding silver, nickel, arsenic and phosphorus)

8.2 Cakes, billets and wire bars shall be substantially free from shrink, holes, cracks, cold sets, pits, sloppy edges, concave tops and other similar defects in set or casting.

NOTE — This does not apply to ingots and ingot bars, in which physical defects are of minor consequence.

9 ELECTRICAL PROPERTIES

9.1 Copper shall have resistivity at a temperature of 20°C (Annealed) not exceeding the values given in Table 5.

9.1.1 Information on relationship of electrical resistivity (mass and volume) and conductivity is given in Annex B, which is based on standards fixed by the International Electrotechnical Commission.

9.2 Resistivity Test

9.2.1 Samples for the resistivity test shall be prepared in the form of wire of approximately 2.0 mm diameter, which shall be annealed at a temperature of 525 to 550°C for not less than 30 min. The measurement of resistivity shall be carried out to an accuracy of at least one part in a thousand. For the test method, reference may be made to IS 3635. The length of sample selected for the test shall be sufficient to give the accuracy required and shall be suitable for the method of testing employed. If the sample fails, a fresh sample may be taken and the resistivity checked.

10 HYDROGEN EMBRITTLEMENT TEST FOR Cu-DHP, Cu-DPA and Cu-ATP

10.1 The edges of the test pieces may be carefully rounded and smoothened longitudinally. After being exposed to an atmosphere of hydrogen for 30 min at 800 to 875°C and subsequently cooled in the container itself (out of contact with air), the test pieces shall be subjected to a close bend test as described in **10.1.1** to **10.1.3**.

10.1.1 The test piece *AB* is bent by steadily applied pressure, or a succession of blows, at right angles to the length *AC* and flattened close until *A* assumes the position indicated by *D* (*see* Fig. 2)

10.1.2 The convex surface of the bend portion shall not reveal any cracks, openings or porosity.

10.1.3 For the purpose of this test, one piece of copper shall be selected from each hundred, or part thereof in the consignment or order, and the test piece taken from the pieces so selected.

11 SAMPLING AND CRITERIA FOR CONFORMITY

11.1 Lot

11.1.1 For the determination of the copper content, consignments up to a total mass of about 300 t should be considered as a single lot, provided that the whole of the consignment is of the same charge and consists of uniform shapes. Consignments exceeding 300 t in total mass should be divided into lots of approximately equal size.

11.1.2 If a consignment consists of several charges and/or different shapes, the consignment should be divided into lots according to charges and shapes. The size of the

Table 5 Physical Properties
(*Clauses* 9.1 *and* 11.2.1)

Designation	Electrical Properties				Tests Required		
	Mass Resistivity, ohm g/m² *Max*	Nominal Volume, ohm mm²/m *Max*	Nominal Conductivity, *Min*		Chemical Analysis	Mass Resistivity Test	Hydrogen Embrittlement Test
			MS/m	Percent IACS			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Cu-CATH-1	0.151 76	0.170 7	58.58	101.0	×	×	
Cu-CATH-2	0.153 28	0.172 4	58.00	100.0	×	×	
Cu-ETP	0.153 28	0.172 4	58.00	100.0	×	×	
Cu-FRHC	0.153 28	0.172 4	58.00	100.0	×	×	
Cu-FRTP-1					×		
Cu-FRTP-2					×		
Cu-DHP					×		×
Cu-ATP					×		
Cu-DPA					×		×

NOTE — The values for nominal volume resistivity and nominal conductivity are given for guidance only.

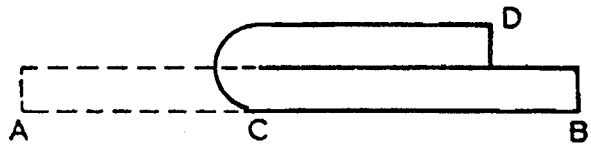

FIG. 2 CLOSE BEND TEST

lots depends on the charges and shapes forming the consignment concerned and/or on the arrangements made between the interested parties.

11.2 Sampling

11.2.1 Unless agreed otherwise, the method of drawing representative samples of the material and the criteria for conformity shall be as given in Annex C. The tests required for conformity shall be as given in Table 5.

11.2.2 In case of dispute concerning the chemical analysis or physical properties, the method and rate of sampling, each inspection lot shall be agreed between the supplier and the purchaser and if necessary, any mutually accepted arbitrator.

12 TEST CERTIFICATE

The supplier if required, shall issue test certificate, that the material complies with the requirements of the standard.

13 MARKING

13.1 All shapes intended for fabrication shall be marked to identify the batch/lot number and manufacturer's trade-mark.

13.2 BIS Certification Marking

The material may also be marked with the Standard Mark.

13.2.1 The use of Standard Mark is governed by the provision of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of the conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

14 INFORMATION TO BE GIVEN BY THE PURCHASER

The purchaser should provide following information at the time of placing the order:

a) Quantity of product required (kg or t);
b) IS No.;
c) Marking details;
d) Material designation;
e) Cross-sectional shape required of billet, wire bar, cake and ingot;
f) Dimensional tolerances;
g) Sampling and criteria for conformity; and
h) Whether test certificate is required.

ANNEX A
(Foreword)

CORRELATION OF THE MATERIAL DESIGNATION OF OLD IS GRADES WITH NEW IS GRADES

Old Designation (1)	New Designation (2)
—	Cu-CATH-1 (New Grade added)
CATH	Cu-CATH-2
ETP	Cu-ETP
FRHC	Cu-FRHC
FRTP-1	Cu-FRTP-1
FRTP-2	Cu-FRTP-2
DHP	Cu-DHP
ATP	Cu-ATP
DPA	Cu-DPA

ANNEX B
(*Clause* 9.1.1)

INFORMATION ON ELECTRICAL RESISTIVITY AND CONDUCTIVITY RELATIONSHIPS

B-1 STANDARD VALUES

B-1.0 The following values fixed by the International Electrotechnical Commission for 'Standard Annealed Copper' have been taken as standard values for annealed high-conductivity copper [that is International Annealed Copper Standard (IACS)].

B-1.1 At a temperature of 20°C the volume resistivity of standard annealed copper is 1/58 (or 0.017 24.....) ohm mm^2/m.

B-1.2 At a temperature of 20°C the density of standard annealed copper is 8.89 g/cm^3.

B-1.3 At a temperature of 20°C the coefficient of linear expansion of standard annealed copper is 0.000 017/°C.

NOTE — The above value for the coefficient of linear expansion may be applied to annealed copper over a temperature range of 0 to 150°C.

B-1.4 At a temperature of 20°C the coefficient of variation of resistance with temperature of standard annealed copper measure between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, is 0.003 93

$$\left[\text{or } \frac{1}{254.45...}\right] /°C.$$

B-1.5 The relationship of volume resistivity and mass resistivity is derived from **B-1.1** and **B-1.2** that at a temperature of 20°C the mass resistivity of standard annealed copper is:

$$\frac{1}{58} \times 8.89 = 0.153\ 28 \text{ ohm g/m}^2$$

ANNEX C
(*Clauses* 11.2.1)

SAMPLING AND CRITERIA FOR CONFORMITY

C-1 SAMPLING

C-1.1 The number of cast wire bar/cake/ingot/billets to be inspected from a lot for freedom from defects (*see* **8**) and size, shape and mass (*see* **5**) shall be in accordance with col 1 and col 2 of Table 6.

C-1.2 The lot shall be considered as conforming to the requirements of this standard, if the number of defectives (those failing to satisfy the requirements given in **5** or **8**) is less than or equal to the permissible number given in col 3 of Table 6. In the case of those lots which have been found unsatisfactory according to Table 6, all the cast

Table 6 Number of Cast Wire Bar/Cake/Ingot/Billets to be Inspected and Permissible Number of Defectives
(*Clauses* C-1.1 *and* C-1.2)

No. of Cast Wire Bar/Cake/Ingot/Billets in the Lot (1)	No. of Cast Wire Bar/Cake/Ingot/Billets to be Inspected (2)	Permissible Number of Defectives[1] (3)
Up to 50	All	+[2]
51-150	50	1
151-300	80	2
301-500	125	3
501 and above	200	5

[1] This ensures that lots containing only one percent defective cast wire bar/cake/ingot/billets or less will be accepted most of the times.
[2] The defectives encountered shall be removed and only the remaining cast wire bar/cake/ingot/billets shall be accepted.

wire bar/cake/ingot/billets may be inspected for freedom from defects and size, shape and mass subject to agreement between the purchaser and the manufacturer.

C-2 CHEMICAL COMPOSITION

C-2.1 Sampling

For sampling, take three pieces as gross samples from each of the lots (charges, shapes) according to **11.1** unless otherwise agreed to between the interested parties.

C-2.2 Remove surface contamination, if any, from the three pieces, and also remove any surface oxide layer from those areas where samples are to be taken. Drill holes completely through each piece, or if the pieces are too thick, drill holes from two opposite sides to the centre. Do not use lubricants or similar substances. The drill should be of cemented carbide or other suitable hard metal (such as bonded tungsten carbide drill or carbide tipped drill) and should not contain substantial quantities of iron. The drill should be 10 to 15 mm in diameter and be designed to produce drillings as small and short as possible. The drilling should have a metallic luster and should be free of oxidation. Do not force the drill to such an extent as to cause oxidation of the chips. If oxidized chips are obtained, reject all the chips from that hole and drill another hole adjacent to the original to provide an unoxidized sample.

C-2.3 Use a uniform hole pattern over the three pieces of the gross sample taken from each lot. In principle, distribute the holes in such a way that at one hole is drilled within each 25 cm^2 of the surface area. Mix thoroughly the drillings obtained in this way.

C-2.4 If less than 2 kg (approximate value) of drillings are obtained per lot, increase the number of holes by whole multiples of the original number of holes. If, on the other hand, more than 2 kg (approximate value) of drillings are obtained per lot, reduce them to about 2 kg by quartering.

C-2.5 Divide the 2 kg sample into four parts for analysis of about 500 g each, place each in a bottle, label, and seal. Send one sample to each of the interested, parties and retain one as a referee sample and another as a reserve sample, or distribute them according to the arrangements made between the interested parties.

C-3 ELECTRICAL PROPERTIES

C-3.1 Sampling

Three test pieces shall be made from each lot for testing of electrical properties. As agreed to between the purchaser and the manufacturer the test pieces may be made in the presence of purchaser or his representative.

C-3.2 Criteria for Conformity

If the electrical properties are met by the first test piece, the lot shall be accepted. If the first test piece fails to conform to the specified requirements, the two remaining test pieces shall be tested; and if either of them fails to meet the specified requirements, the whole lot shall be rejected.

C-4 HYDROGEN EMBRITTLEMENT TEST

C-4.1 Three test pieces in each lot shall be subjected to hydrogen embrittlement test for detection of casting defects.

C-4.2 Criteria for Conformity

If any of the test piece selected (*see* **C-4.1**) for the hydrogen embrittlement test fails, a further two test pieces from the same lot shall be selected and tested. If any one of them fails, the whole lot shall be rejected.

ANNEX D
(*Foreword*)

COMMITTEE COMPOSITION

Copper and Copper Alloys Sectional Committee, MTD 8

Organization	*Representative(s)*
Indian Copper Development Centre, Kolkata	DR D. DE SARKAR (***Chairman***)
Agarwal Metal Works, Rewari	SHRI D. K. JAIN SHRI O. P. RANA (*Alternate*)
Alcobex Metals Ltd, Jodhpur	SHRI G. C. KANUNGO SHRI S. D. PUROHIT (*Alternate*)
All India Air Conditioners & Refrigeration Association, Delhi	SHRI A. H. GIDWANI SHRI A. P. KHURANA (*Alternate*)
Bhabha Atomic Research Centre, Mumbai	SHRI V. K. TANGRI SHRI S. K. GUPTA (*Alternate*)
Bharat Electronics Ltd, Bangalore/Ghaziabad	SHRI SRIDHAR S. NADIGER SHRI ANUJ SINGH (*Alternate*)
Bharat Heavy Electricals Ltd, Bhopal	REPRESENTATIVE
Birla Copper Ltd, Bharuch	SHRI A. N. CHAKARVARTI SHRI B. M. SHARMA (*Alternate*)
Crompton Greaves Ltd, Mumbai	REPRESENTATIVE
DGS&D (Quality Assurance Wing), Kolkata/New Delhi	SHRI B. DAS GUPTA SHRI S. K. PANDEY (*Alternate*)
Finolex Cable Ltd, Bangalore	REPRESENTATIVE
Gem Sanitary Appliances Pvt Ltd, Delhi	SHRI B. K. SINGHAL SHRI V. K. CHOWDHARY (*Alternate*)
Hindustan Cables Ltd, Burdwan	SHRI A. K. NAG
Hindustan Copper Ltd, Kolkata	SHRI P. N. GANGOPADHYAY
India Govt Mint, Hyderabad	SHRI M. J. RAY
Indian Telephone Industries Ltd, Bangalore	SHRI V. V. PRABHU SHRI M. DAWOOD (*Alternate*)
Indoswe Engineers Pvt Ltd, Pune	SHRI U. K. JATIA SHRI S. K. JAIN (*Alternate*)
International Copper Promotion Council (India), Mumbai	SHRI NAVEEN SHUKLA SHRI NARSIMHAN (*Alternate*)
Larsen & Toubro Ltd, Mumbai	SHRI R. C. AGARWAL SHRI U. R. JOSHI (*Alternate*)
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(*Continued from second cover*)

The composition of the Committee responsible for the formulation of this standard is given in Annex D.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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