IS : 963 - 1958
(Reaffirmed 1998)
Edition 1.2
(1983-03)

Indian Standard

SPECIFICATION FOR CHROME-MOLYBDENUM STEEL BARS AND RODS FOR AIRCRAFT PURPOSES

(Incorporating Amendment Nos. 1 & 2)

UDC 669.15.26.28-194 : 669-42 : 629.13

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

Price Group 4

Indian Standard

SPECIFICATION FOR CHROME-MOLYBDENUM STEEL BARS AND RODS FOR AIRCRAFT PURPOSES

Steel Sectional Committee, SMDC 5

Chairman

SHRI J. S. VATCHAGANDHY	The Tata Iron & Steel Co Ltd, Jamshedpur; *and* Boilers Sectional Committee (EDC 40), ISI

Members

DR S. N. ANANT NARAYAN	The Mond Nickel Co Ltd, Bombay
SHRI N. C. BAGCHI	Government Test House, Calcutta
SHRI N. C. SEN GUPTA (*Alternate*)	
SHRI S. BANERJEE	Iron & Steel Control (Ministry of Steel, Mines & Fuel), Calcutta
SHRI R. G. BHATAWADEKAR	Ministry of Railways
SHRI K. C. CHOUDHURI (*Alternate*)	
SHRI B. N. CHAUDHURI	Institution of Engineers (India), Calcutta
SHRI K. V. CHINNAPPA	Hindustan Machine Tools Private Ltd, Bangalore
SHRI A. R. IYER (*Alternate*)	
SHRI S. N. CHOUDHURI	Indian Foundry Association, Calcutta
SHRI S. C. BISWAS (*Alternate*)	
DR M. N. DASTUR	M. N. Dastur & Co Private Ltd, Calcutta
SHRI JAI PEARCE (*Alternate*)	
SHRI H. R. DEWAN	Indian Bureau of Mines (Ministry of Steel, Mines & Fuel), Nagpur
SHRI V. S. PRADHAN (*Alternate*)	
DR D. R. DHANBHOORA	The Tata Iron & Steel Co Ltd, Jamshedpur
SHRI S. VISWANATHAN (*Alternate*)	
SHRI P. N. GINWALA	Indian Institute of Metals, Calcutta
SHRI B. N. GUPTA	Steel Re-Rolling Mills Association of India, Calcutta
SHRI P. K. GUPTE	National Metallurgical Laboratory, Jamshedpur
SHRI T. KRISHNAPPA	Mysore Iron & Steel Works, Bhadravati
SHRI N. R. KRISHNASWAMY	Directorate General of Ordnance Factories (Ministry of Defence), Calcutta
DR S. BHATTACHARYA (*Alternate*)	
SHRI S. C. LAHIRY	Inspection Wing, Directorate General of Supplies & Disposals (Ministry of Works, Housing & Supply)
SHRI A. M. MADDOX	Stewarts & Lloyds of India Ltd, Calcutta
SHRI A. D. MAJUMDAR	Hindustan Shipyard Private Ltd, Visakhapatnam
SHRI S. S. KAPADIA (*Alternate*)	

(*Continued on page* 2)

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

(*Continued from page* 1)

Members	
SHRI C. P. MALIK	National Buildings Organization (Ministry of Works, Housing & Supply), New Delhi
SHRI SHRI KRISHNA (*Alternate*)	
SHRI U. G. K. MENON	Naval Chemical & Metallurgical Laboratory, Bombay
SHRI P. S. RAMASWAMY (*Alternate*)	
SHRI E. MULLER	Kalinga Tubes Ltd, Calcutta
DR S. R. PRAMANIK	Hindustan Steel Ltd, (Ministry of Steel, Mines & Fuel), New Delhi
SHRI D. V. REDDI	Defence Metallurgical Research Laboratory (CGDP) (Ministry of Defence)
SHRI Y. K. MURTY (*Alternate*)	
SHRI K. H. SHARMA	Indian Iron & Steel Co Ltd, Burnpur
SHRI VIVEK R. SINHA	Directorate of Technical Development & Production (Air) (Ministry of Defence)
SHRI B. V. TALWAR	J. K. Steel Ltd, Calcutta
DR LAL C. VERMAN (*Ex-officio*)	Director, ISI
SHRI B. S. KRISHNAMACHAR (*Alternate*)	Assistant Director (S & M), ISI
Secretary	
SHRI H. C. SHARMA	Assistant Director (Metals), ISI

Indian Standard

SPECIFICATION FOR CHROME-MOLYBDENUM STEEL BARS AND RODS FOR AIRCRAFT PURPOSES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 8 November 1958, after the draft finalized by the Steel Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 The chrome-molybdenum steel specified in this standard finds extensive use in the manufacture of various aircraft parts and components. It may be welded but is not recommended for heavy sections or parts having a wide variation in thickness.

0.3 Taking into consideration the views of producers and consumers, the Sectional Committee responsible for the preparation of this standard felt that it should be related to the manufacturing practices followed in the country in this field. This consideration led the Sectional Committee to derive assistance from the US Military Specification, MIL-S-6758 Steel : Chrome-Molybdenum (4130) Bars, Rods, and Forging Stock (for Aircraft Applications).

0.4 This standard requires reference to IS : 1608-1960 Method for Tensile Testing of Steel Products Other Than Sheet, Strip, Wire and Tube.

0.5 This edition 1.2 incorporates Amendment No. 2 (March 1983). Side bar indicates modification of the text as the result of incorporation of the amendment.

0.6 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 : 2-1949 Rules for Rounding Off Numerical Values. The number of significant places retained in the rounded off value should be the same as that of the specified value in the standard.

0.7 In view of the Government of India's decision to introduce in the country a uniform system of weights and measures based on the metric system, all values appearing in this standard are given in metric units except those which are inter-related with standard test methods employing fps units only (*see* **7.1.4**, **7.6.2**, **A-3.3** and **B-1.3**). However,

*Since revised.

in order to help the industry to familiarize itself with the metric system, equivalents in inch system are also given. The inter-conversion of values has been done generally in accordance with IS : 787-1956 Guide for Inter-Conversion of Values from One System of Units to Another.

0.7 This standard is intended chiefly to cover the technical provisions relating to the material, and it does not include all the necessary provisions of a contract.

1. SCOPE

1.1 This standard covers the requirements for chrome-molybdenum steel bars and rods for aircraft purposes.

2. PHYSICAL AND SURFACE CONDITIONS

2.1 Bars and rods for forging shall be delivered as rolled or forged, unless the order states otherwise.

2.2 Bars and rods for machining shall be delivered in any one of the following heat-treated conditions, unless the order states otherwise:

a) Annealed,

b) Normalized,

c) Normalized and tempered, and

d) Hardened and tempered.

2.3 Bright bars shall be delivered in the finally heat-treated condition in any one of the following finishes, unless the order states otherwise:

a) Pickled or blast cleaned;

b) Rough turned;

c) Cold finished;

d) Turned, ground and polished; and

e) Reeled and skinned.

2.3.1 The final heat-treatment to be given before or after any of the above finishing operations is left to the option of the supplier, unless the order states otherwise.

3. MANUFACTURE

3.1 The steel shall be manufactured by acid or basic open hearth or electric furnace process.

3.2 The steel shall be of high grade quality, satisfactory for the fabrication of aircraft parts which may be subject to magnaflux or any other approved process of inspection.

3.3 Sufficient discard shall be taken from the top and bottom of each ingot to ensure freedom from piping and undue segregation, as judged by the transverse test piece taken from the topmost part of the billet next to the top discard.

4. FREEDOM FROM DEFECTS

4.1 Material shall be sound, of uniform quality and condition, free from pipes, and shall not contain laps, cracks, twists, seams, or other defects detrimental to the fabrication or performance of parts.

4.2 Cold finished bars and rods shall be entirely free from scale or surface imperfections. Cold finishing shall be accomplished after all heat-treatment operations have been completed; however, stress relieving may be carried out after cold finishing.

4.3 The supplier shall satisfy himself, by metallurgical examination for cleanness that the cast is free from harmful inclusions. A standard of acceptance, if so desired, may be agreed between the supplier and the purchaser.

5. ROUGH MACHINING

5.1 All bars and rods shall be made from rough-machined or ground ingots or blooms, or shall themselves be rough machined or ground. Rough machining may be replaced by a deseaming process at the discretion of the purchaser.

6. CHEMICAL COMPOSITION

6.1 The analysis of steel shall be as given below. The analysis of steel shall be carried out either by the method specified in IS : 228* and its relevant parts or any other established instrumental/chemical method. In case of dispute the procedure given in IS : 228* and its relevant parts shall be referee method. However, where the method is not given in IS : 228* and its relevant parts, the referee method shall be as agreed to between the purchaser and the manufacturer.

Constituent	*Percent*
Carbon	0.26 to 0.35
Manganese	0.40 to 0.60
Phosphorus, *Max*	0.040
Sulphur, *Max*	0.040
Silicon	0.20 to 0.35
Chromium	0.80 to 1.10
Molybdenum	0.15 to 0.25
Nickel (residual), *Max*	0.25

6.2 The supplier shall, when required, supply a copy of the works analysis of the material. The works analysis is defined as the routine analysis by the manufacturer in order to control the quality of the material.

*Methods for chemical analysis of steels.

7. PHYSICAL AND MECHANICAL PROPERTIES

7.1 Hardenability (*see* Appendix A).

7.1.1 The hardenability test shall be carried out only when agreed to by the supplier and the purchaser.

7.1.2 Two or more samples for end-quench-hardenability test shall be selected from each heat of steel.

7.1.3 The steel shall be normalized prior to machining the test specimen by heating to 900 ± 5°C, holding at this temperature for one hour and cooling in still air. The test specimen shall be austenitized at 870 ± 5°C.

7.1.4 End-quench-hardenability values for the steel in all specified conditions shall be Rockwell C-35 or 350 VPN minimum at $\frac{5}{16}$ in and Rockwell C-28 or 285 VPN minimum at $\frac{8}{16}$ in.

7.2 Grain Size (*see* Appendix B).

7.2.1 One or more samples shall be selected to represent each heat of steel from which the material is rolled.

7.2.2 The austenitic grain size, when determined by McQuaid-Ehn test shall be predominantly ASTM No. 5 or finer, with grains as large as ASTM No. 3 permissible.

7.3 Macro-Examination

7.3.1 Two or more samples shall be selected to represent each heat of steel.

7.3.2 The test specimens shall be cut from the ends of the bars or rods selected and shall represent the entire cross-section of the bar or rod. One of the faces of the specimen representing the cross-section of the bar or rod shall be finished flat and smooth by a fine machine cut or grinding. A sulphur print of the finished face of the specimen shall be taken, followed, if necessary, by a light acid etch in an aqueous solution containing 50 percent hydrochloric acid by volume and maintained at a temperature of 65 to 75°C.

7.3.3 Examination of the sulphur print and the light acid etch shall show no evidence of pipes, internal cracks, excessive segregation, flakiness, or other injurious defects.

7.4 Decarburization (Not applicable to material intended for reforging).

7.4.1 The decarburization test shall be carried out only when specially required by the purchaser.

7.4.2 The purchaser may select samples for determination of depth of the decarburization.

7.4.3 The depth of decarburization shall be determined by examination of a metallographic specimen or specimens representing the peripheral region of the bar or rod. This specimen shall be polished, etched with 5 percent nital and examined at 100 diameters magnification.

7.4.4 Material supplied in rough turned, or turned ground and polished, or reeled and skinned surface conditions shall be free from decarburization.

7.4.5 Unless specified otherwise, the depth of any decarburization for material supplied in pickled or blast cleaned, or cold finished surface conditions, shall be not greater than the following limits:

a) *For material ordered to metric sizes*

NOMINAL DIAMETER OR DISTANCE BETWEEN OPPOSITE FACES	MAXIMUM DEPTH OF DECARBURIZATION*
mm	mm
Up to 10.0 inclusive	0.25
Over 10.0 ,, 15.0 inclusive	0.30
Over 15.0 ,, 20.0 inclusive	0.35
Over 20.0 ,, 25.0 inclusive	0.40
Over 25.0 ,, 35.0 inclusive	0.50
Over 35.0 ,, 50.0 inclusive	0.60
Over 50.0 ,, 65.0 inclusive	0.75
Over 65.0 ,, 80.0 inclusive	0.90

*The value specified as the maximum depth of decarburization is the sum of the complete plus the partial decarburization. Local decarburization may be disregarded, provided it does not exceed the limit specified by more than 0.13 mm and the width is 1.65 mm or less.

b) *For material ordered to inch sizes*

NOMINAL DIAMETER OR DISTANCE BETWEEN OPPOSITE FACES	MAXIMUM DEPTH OF DECARBURIZATION*
in	in
Up to 0.375 inclusive	0.010
Over 0.375 ,, 0.500 inclusive	0.012
Over 0.500 ,, 0.625 inclusive	0.014
Over 0.625 ,, 1.000 inclusive	0.017
Over 1.00 ,, 1.50 inclusive	0.020
Over 1.50 ,, 2.00 inclusive	0.025
Over 2.00 ,, 2.50 inclusive	0.030
Over 2.50 ,, 3.00 inclusive	0.035

*The value specified as the maximum depth of decarburization is the sum of the complete plus the partial decarburization. Local decarburization may be disregarded, provided it does not exceed the limit specified by more than 0.005 in and the width is 0.065 in or less.

7.5 Hardness (For material supplied in annealed, or normalized and tempered conditions.)

7.5.1 At least 5 percent of bars supplied, with a minimum of 5 bars of each physical condition and size, shall be tested to ascertain conformity with the permissible hardness values. When less than 5 bars are ordered, each bar shall be tested.

7.5.2 For material supplied in the following surface conditions, the hardness of the bars and rods, when tested with any approved form of hardness tester, shall be as given against each:

SURFACE CONDITION	HARDNESS *Max*
Black as forged or rolled Pickled or blast cleaned or rough turned	Rockwell C-21 (Brinell 229)
Cold finished	Rockwell C-23 (Brinell 241)

7.6 Tensile Properties

7.6.1 One or more tensile test samples shall be selected from bars or rods produced under the same processing conditions, from the same heat, of the same physical condtions, of the same size, essentially uniform in all respects, and submitted for inspection at one time.

7.6.1.1 For bars and rods up to 38 mm (or 1½ in) in diameter or thickness, the axis of the test specimen shall coincide with the central axis of the bar or rod; for bars and rods of diameter or thickness 38 mm (or 1½ in) and over, the axis shall be located midway between the centre and the surface of the bar or rod. The axis of tensile test specimen shall be parallel to the direction of rolling or drawing.

7.6.2 Test samples shall be hardened in oil at a temperature of 855 to 885°C and tempered at a temperature of not less than 510°C. The test samples, when tested in accordance with IS : 1608-1960, shall show the following properties for sizes up to 38 mm in the least dimension as specified below:

ULTIMATE TENSILE STRESS, *Min*		YIELD STRESS AT 0.2 PERCENT SET, *Min*		ELONGATION ON GAUGE LENGTH $4\sqrt{S_o}$ PERCENT *Min*	REDUCTION OF AREA PERCENT *Min*
kg/mm²	tons/in²	kg/mm²	tons/in²		
86.6	55.0	70.9	45.0	16	50

7.6.2.1 For sections larger than 38 mm (or 1½ in) in the least dimension, the mechanical properties shall be subject to agreement between the supplier and the purchaser.

8. CALCULATION OF WEIGHT

8.1 When the material is ordered by weight, it shall be calculated on the basis that it weighs 0.784 kg/cm^2 cross-section per metre run (or 3.396 lb/in^2 cross-section per foot run).

9. ROLLING TOLERANCES

9.1 Where the specified weight is not stated to be either a maximum or a minimum, the rolling margin as percentage of specified weight shall be as follows:

NOMINAL SIZE	ROLLING MARGIN PERCENT	TOTAL ROLLING MARGIN PERCENT
For flat bars, all thickness	± 2½	5
For round, square and hexagonal bars up to 9.5 mm (or $\frac{3}{8}$ in) in diameter or thickness	± 4	8
Over 9.5 mm (or $\frac{3}{8}$ in) in diameter or thickness	± 2½	5

9.2 When the round and hexagonal bars are ordered for further machining operation, they may be supplied to the following tolerances on diameter in the case of round bars and on width across the flat surfaces in the case of hexagonal bars, unless otherwise agreed upon between the supplier and the purchaser:

DIAMETER IN THE CASE OF ROUND BARS AND WIDTH ACROSS THE FLAT SURFACES IN THE CASE OF HEXAGONAL BARS	TOLERANCE
a) *For material ordered to metric sizes*	
	mm
Up to 19 mm inclusive	± 0.40
Over 19 mm to 25 mm inclusive	± 0.50
Over 25 mm	± 0.65
b) *For material ordered to inch sizes*	
	in
Up to ¾ in inclusive	± 0.015
Over ¾ in to 1 in inclusive	± 0.020
Over 1 in	± 0.025

9.3 When the rolled round bars are ordered for reeling and skinning the bars shall be supplied to the following tolerances on diameter:

DIAMETER OF BARS	TOLERANCE
a) *For material ordered to metric sizes*	
	mm
Up to 19 mm inclusive	+ 0.75 – 0.00
Over 19 mm to 25 mm inclusive	+ 1.00 – 0.00
Over 25 mm	+ 1.25 – 0.00
b) *For material ordered to inch sizes*	
	in
Up to ¾ in inclusive	+ 0.030 – 0.000
Over ¾ in to 1 inclusive	+ 0.040 – 0.000
Over 1 in	+ 0.050 – 0.000

9.3.1 When the round bars are ordered for reeling and skinning, the out of roundness shall not exceed 0.75 mm (or 0.030 in).

9.3.2 When the reeled bars are ordered for skinning purpose, the bars shall not have a camber of more than 1 mm in every 2 mm length (or $\frac{1}{32}$ in in every 5 ft length).

9.4 If skinned bars are ordered, they shall be supplied with the tolerances specified in **9.4.1** to **9.4.3**.

9.4.1 The bars shall be supplied to a total tolerance of 0.15 mm (or 0.006 in) on diameter.

9.4.2 Variation in diameter at any portion of the bar shall not exceed by 0.05 mm (or 0.002 in).

9.4.3 Out of roundness shall not exceed by 0.025 mm (or 0.001 in).

10. REJECTION AND RETESTS

10.1 Where any lot of material fails to meet the mechanical test or hardness test requirements of this specification, the material may be re-heat-treated and resubmitted for test.

10.2 Where a sample or specimen, fails to satisfy any of the tests specified, the entire lot of material represented shall be rejected.

11. MARKING

11.1 The manufacturer shall mark the material in such a way as to enable all the finished steel to be traced to the original cast and, in the case of heat-treated material, to the heat-treatment batch also.

12. PRESERVATION AND PACKAGING

12.1 Bars and rods, furnished in other than black as forged or rolled condition, shall be suitably greased or oiled for protection against corrosion.

12.2 Material under 25 mm (or 1 in) in diameter or thickness shall be bundled and suitably protected against surface injury during transportation.

12.3 Material shall be properly grouped by size and its physical and surface conditions.

13. CERTIFICATE OF COMPLIANCE

13.1 The supplier shall certify that the material complies with the requirements of this standard.

14. INSPECTION AND TESTING FACILITIES

14.1 If the purchaser wishes to inspect the material at the supplier's works, he shall notify the supplier at the time of placing the order, in which case the supplier shall afford the purchaser all reasonable facilities for satisfying himself that the material is being manufactured fully in accordance with the requirements of this standard and for this purpose the purchaser shall have free access to supplier's works at all reasonable times.

14.2 The supplier shall, at his own expense, furnish and prepare the necessary test pieces and supply labour and appliances for such testing as may be carried out at his premises in accordance with the requirements of this standard. Failing facilities for making the prescribed tests at his own works, the supplier shall bear the cost of the tests carried out elsewhere.

APPENDIX A

(*Clause* 7.1)

END-QUENCHING TEST FOR HARDENABILITY

A-1. TEST SPECIMEN

A-1.1 The test specimen shall be 25 mm (or 1 in) in diameter and 75 mm (or 3 in) or 100 mm (or 4 in) in length (*see* Fig. 1) with means of hanging it in a vertical position for end-quenching. The specimen shall be machined from a bar of a size to permit the removal of all decarburization in' machining to 25 mm (or 1 in) round. The end of the specimen to be water-cooled shall have a reasonably smooth finish, preferably produced by grinding.

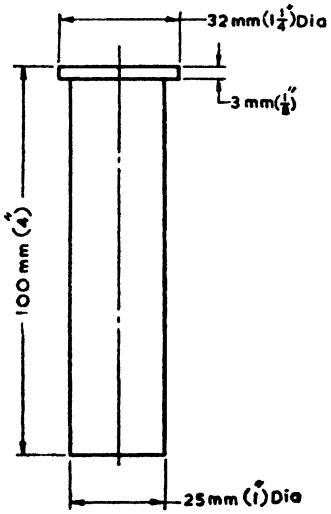

FIG. 1 PREFERRED TEST SPECIMEN

A-2. APPARATUS

A-2.1 The apparatus shall consist of the following:

a) *Water-Quenching Device* — A water-quenching device of suitable capacity to provide a vertical stream of water that can be controlled at height of 65 mm (or 2½ in) when passing through

an orifice 13 mm (or ½ in) in diameter. The water supply line shall also be provided with a quick opening valve.

b) *Support for Test Specimen* — A fixture for supporting the test specimen vertically so that the lower end of the specimen is 13 mm (½ in) above the orifice of the water-quenching device.

A-3. PROCEDURE

A-3.1 Heating — The test specimen shall be heated to the austenizing temperature within 30 to 40 minutes and held at that temperature for 20 minutes. It is important to heat the specimen in such an atmosphere that practically no scaling and a minimum of decarburization take place. This may be accomplished by heating the specimen in a vertical position in a container with an easily removable cover containing a layer of cost iron chips with the bottom face of the specimen resting on the chips. When a container is used, it is necessary to determine, by means of a thermo-couple, the time required for the test specimen to reach the required temperature.

A-3.2 Quenching — The water-quenching device shall be adjusted so that the stream of water rises to a free height of 65 mm (or 2½ in) above the 13 mm (or ½ in) orifice, without the specimen in position. The support for specimen shall be dry at the beginning of each test. The heated specimen shall then be placed in the support so that its bottom face is 13 mm (or ½ in) above the orifice, and the water turned on by means of the quick opening valve. The time between removal of the specimen from the furnace and the beginning of the quench should be not more than 5 seconds. The stream of water at a temperature of 4.5° to 29.5°C shall be directed against the bottom face of the specimen for not less than 10 minutes. So far as possible, a condition of still air shall be maintained around the specimen during cooling. If the specimen is not cold when removed from the fixture, it shall be immediately quenched in water.

A-3.3 Hardness Measurement — Hardness testing shall be made on the test specimen in steps of $\frac{1}{16}$ in. The series of hardness readings shall be numbered from quenched end of the specimen. The surfaces on which hardness readings are made shall be mutually parallel flat surfaces, 180 degrees apart, ground lengthwise of the specimen. The flat surfaces shall be ground 0.38 mm (or 0.015 in) in depth. When a flat surface is used as a base, previous indentations shall be removed by grinding.

The exact position of each hardness reading with respect to the quenched end of the specimen shall be known. Care shall be taken to

ensure no vertical movement in the assembly of test specimen, anvil, and elevating screw when the major load is applied.

The grinding operation for preparing the flat surfaces shall be carried out with great care. Surfaces shall be flat. To ensure against reporting hardnesses taken on surfaces that are tempered by grinding, the following etching procedure is recommended:

Etchant

Solution No. 1 — 5 parts of nitric acid (sp gr 1.42) and 95 parts of water by volume

Solution No. 2 — equal parts of hydrochloric acid (sp gr 1.18) and water by volume

Etching Procedure — Wash the specimen in hot water. Etch in solution No. 1 until black. Wash in hot water. Immerse in solution No. 2 for 3 seconds and wash in hot water. Dry in air blast.

The presence of darkened areas in the martensitic zone indicates that tempering has occured. All evidence of tempering shall be removed before hardness tests are made. This may be accomplished by resurfacing and again etching or by preparing new flat surfaces.

A-4. TEST SPECIMEN FOR SPECIAL APPLICATION

A-4.1 When the test specimen available is smaller in size than that given under **A-1.1**, then an insert test specimen as illustrated in Fig. 2 shall be used and tested as described in **A-4.2**.

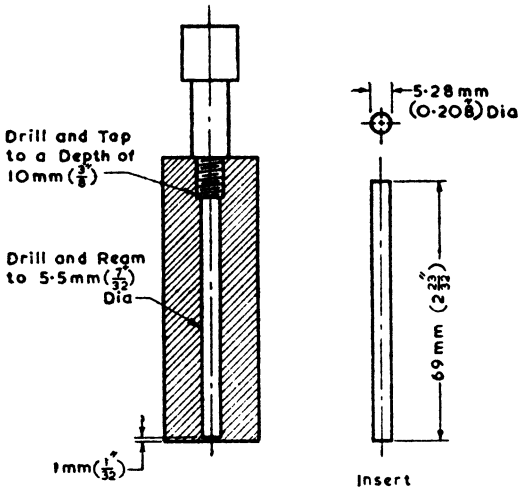

FIG. 2 DRILLED BAR SPECIMEN FOR STEEL AVAILABLE ONLY IN SMALL SIZES

A-4.2 About 0.2 g of Woods metal (50 percent bismuth, 25 percent lead and 25 percent tin, m.p 93°C) shall be placed in the bottom of the test sheath (Fig. 2), the small test specimen inserted in the sheath, and the sheath warmed to a temperature above the melting point of Woods metal. The sheath shall preferably be made from a plain low carbon steel. After the Woods metal is molten, the stud shall be screwed in place so that the specimen is forced firmly against the bottom of the hole. The assembly shall then be heated and quenched in accordance with **A-3.1** and **A-3.2**. After the quench, the assembly shall be warmed in boiling water to melt the Woods metal and the specimen removed. Hardness measurement shall then be made on the specimen as specified in **A-3.3**.

APPENDIX B

(*Clause* 7.2)

McQUAID-EHN TEST FOR DETERMINATION OF AUSTENITIC GRAIN SIZE

B-1. PROCEDURE

B-1.1 Carburize the specimen at 925°C for 6 to 8 hours.

B-1.2 The hypereutectoid zone of the specimen will reveal the austenitic grain size where it is outlined by the cementite precipitated in the grain boundaries. Etch the metallographic specimen with a suitable etchant and examine under the microscope at 100 diameters magnification.

B-1.3 Absolute grain size may be calculated from Table I which shows the sizes as they appear under microscope and also the actual grain size.

TABLE I GRAIN SIZE RELATIONSHIPS, ACTUAL AND AS OBSERVED AT 100 DIAMETERS MAGNIFICATION

(*Clause* B-1.3)

ASTM Grain Size Number	Number of Grains Per Inch Square as Viewed at 100 Diameters		Calculated Diameter of Average Circular Cross-Section of Equivalent Spherical Grain (Not Magnified)		Calculated Mean Average of Cross-Section of Grain (Not Magnified)	
	Mean	Range	in	mm	in^2	mm^2
1	1	¾ to 1½	0.011 30	0.287	0.000 1	0.06
2	2	1½ ,, 3	0.008 00	0.203	0.000 05	0.03
3	4	3 ,, 6	0.005 67	0.144	0.000 025	0.016
4	8	6 ,, 12	0.004 00	0.101	0.000 012 5	0.008 0
5	16	12 ,, 24	0.002 83	0.071 8	0.000 006 25	0.004 03
6	32	24 ,, 48	0.002 00	0.050 7	0.000 003 13	0.002 02
7	64	48 ,, 96	0.001 42	0.035 9	0.000 001 56	0.001 01
8	128	96 ,, 192	0.001 00	0.025 4	0.000 000 78	0.000 50

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed by Technical Committee : SMDC 5 and amended by SMDC 19

Amendments Issued Since Publication

Amend No.	Date of Issue
Amd. No. 1	Incorporated earlier
Amd. No. 2	March 1983

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002. Telegrams: Manaksanstha
Telephones: 323 01 31, 323 33 75, 323 94 02 (Common to all offices)

Regional Offices:		Telephone
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	323 76 17 323 38 41
Eastern	: 1/14 C. I. T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700054	337 84 99, 337 85 61 337 86 26, 337 91 20
Northern	: SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43 60 20 25
Southern	: C. I. T. Campus, IV Cross Road, CHENNAI 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	832 92 95, 832 78 58 832 78 91, 832 78 92

Branches : AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. NALAGARH. PATNA. PUNE. RAJKOT. THIRUVANANTHAPURAM. VISHAKHAPATNAM