भारतीय मानक
Indian Standard

IS 11169 (Part 1) : 2022

श्रतप्त शीर्षन/श्रतप्त बहिर्वेधन प्रयोग के लिए इस्पात — विशिष्टि

भाग 1 पिटवाँ कार्बन और मिश्रधातु इस्पात

(पहला पुनरीक्षण)

Steels for Cold Heading/Cold Extrusion Applications

Part 1 Wrought Carbon and Alloy Steels

(First Revision)

ICS 77.140.10

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September 2022 **Price Group 14**

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Alloy Steels and Forgings Sectional Committee had been approved by the Metallurgical Engineering Division Council. This standard (Part 1) does not cover stainless steels which are covered in Part 2.

This standard was first published in 1984. While reviewing this standard, in the light of experience gained during these years, the Committee decided to revise it to bring in line with the present manufacturing and trade practices being followed in the country in this field.

A large quantity of wrought carbon and low alloy steels are manufactured in India for cold heading/cold extrusion applications in the form of wire, wire rod and bars. Some important uses for these are cold heading quality fasteners, ball pins, shafts, gears mainly in automotive industries. Since demand and use for cold heading/cold extrusion grades available in other international standards and practically developed grades increased over the years, the committee, therefore, decided to revise by including all available cold heading/cold extrusion grades in various standards which are being used by the Indian Industry.

In addition to incorporating amendment issued to previous version, the following important changes are made in this revision:

i) Grades of majorly used cold heading/cold extrusion quality are included;
ii) Nomenclature of new grades is introduced as per IS 1762 Part 1;
iii) Mechanical properties in various delivery conditions are introduced;
iv) Provision for ordering steel wire/wire rod/bar based on hardenability is incorporated;
v) Dimensional tolerances have been modified;
vi) Surface quality criterion is modified;
vii) Upsetting test criterion is modified by allowing acceptance limits to be agreed upon between manufacturer and purchaser;
viii) Methods of mechanical and metallurgical tests have been updated;
ix) Decarburization limits have been modified;
x) A comparative list indicating grades covered in various designation systems is added.

During the revision of this standard assistance has been derived from the following:

ISO 4954	Steels for cold heading and cold extruding
SAE J403	Chemical Compositions of SAE Carbon Steels
SAE J404	Chemical Compositions of SAE Alloy Steels

The Composition of the Committee and the Panel responsible for the formulation of this standard is given at Annex F.

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 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STEELS FOR COLD HEADING/COLD EXTRUSION APPLICATIONS
PART 1 WROUGHT CARBON AND ALLOY STEELS
(First Revision)

1 SCOPE

1.1 This standard specifies requirements of unalloyed and alloyed steels which are intended for cold heading or cold extruding applications and are delivered as bars, wire rods or wires with nominal sizes 2 mm to 100 mm.

1.2 This standard covers the following groups of steels for cold heading and cold extruding:

a) steels not intended for heat treatment (see Annex A);
b) case-hardening steels (see Annex B); and
c) steels for quenching and tempering (see Annex C).

1.3 This standard is not applicable to the properties of cold headed/cold extruded parts.

2 REFERENCES

The standards listed below contain provisions, which through reference in this text constitute provisions 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*
228 (in various parts)	Methods for chemical analysis of steels
1956 (Part 1) : 1976	Glossary of terms relating to iron and steel: Part 1 General metallurgy, heat treatment and testing (*first revision*)
1956 (Part 2) : 2018	Glossary of terms relating to iron and steel: Part 2 Steel making (*second revision*)
1956 (Part 3) : 2019	Glossary of terms relating to iron and steel: Part 3 Long products including bars rods sections and wires (*second revision*)
1608 (Part 1) : 2018/ ISO 6892-1 : 2016	Metallic materials tensile testing: Part 1 Method of test at room temperature (*fifth revision*)
1500 (Part 1) : 2019/ ISO 6506-1 : 2014	Metallic materials — Brinell hardness test: Part 1 Test method (*fifth revision*)
1501 (Part 1) : 2020/ ISO 6507-1 : 2018	Metallic materials — Vickers hardness test: Part 1 Test method (*fifth revision*)
1586 (Part 1) : 2018/ ISO 6508-1 : 2016	Metallic materials — Rockwell hardness test: Part 1 Test method (*fifth revision*)
3711 : 2020/ ISO 377 : 2017	Steel and steel products — Location and preparation of samples and test pieces for mechanical testing (*third revision*)
3703 : 2004	Recommended practice for magnetic particle flaw detection (*second revision*)
3739 :1987	Dimensional tolerances for carbon and alloy constructional steel (*first revision*)
3848 : 1981	Method for end quench test for hardenability of steel (*first revision*)
4163 : 2021/ ISO 4967 : 2013	Steel — Determination of content of non-metallic Inclusions — Micrographic method using standard diagrams (*third revision*)
4748 : 2021/ ISO 643 : 2019	Steel — Micrographic determination of the apparent grain size (*second revision*)

IS No.	*Title*
6396 : 2000	Methods of measuring decarburized depth of steel (*second revision*)
13015 : 1991	Macro etch testing, inspection and rating of steel products
13190 : 1991	Recommended practice for eddy current examination by rotating probe — Method of Round Steel Bars
IS/ISO 14284 : 1996	Steel and iron — Sampling and preparation of samples for the determination of chemical composition
8910 : 2010/ ISO 404 : 1992	General technical delivery requirements for steel products (*first revision*)
IS/ISO 16124 : 2004	Steel wire rod — Dimensions and tolerances
1762 (Part 1) : 1974	Code for designation of steels

3 TERMINOLOGY

For the purposes of this document, the terms and definitions given in IS 1956 Parts 1, 2 and 3 shall apply.

4 SUPPLY OF MATERIAL

4.1 General requirements for the supply of material shall be as laid down in IS 8910.

4.2 Steels covered by this standard shall be supplied in one of the delivery conditions as indicated in Tables A.1, B.1, C.1 as agreed at the time of enquiry and order.

4.3 Information to be given by the Purchaser

The manufacturer shall obtain the following information from the purchaser at the time of enquiry and order:

a) the quantity to be delivered;
b) the product form (bar, wire rod, wire);
c) nominal dimensions, shape along with tolerance on dimensions;
d) for bars, the length and for wire rod and wire, the coil dimensions, that is inner diameter and mass of the coils;
e) the designation of the steel grade given in Tables A.2, B.2, C.2, C.3;
f) condition of delivery as given in Tables A.1, B1 and C.1; and
g) other options and supplementary or special requirements, if required.

5 CLASSIFICATION AND DESIGNATION

5.1 Classification

a) The steel grades which are not intended for heat treatment after cold forming (*see* Annex A) are non- alloy steels.
b) The steel grades of case hardening steels (*see* Annex B), except the steel grades 10C4 to 25C8 (*see* Annex B), and the steel grades for quenching and tempering (*see* Annex C), except steel grades 20C8 to 45C7S3 (*see* Annex C), are alloy steels.

5.2 Designation

For the steel grades covered by this document, the designations as given in the relevant tables have been allocated in accordance with IS 1762 Part 1.

Annex E provides a list of steels given in Annexes A, B and C and the comparable grades covered in various designation systems in other national/international/associations standard.

6 MANUFACTURE

6.1 The manufacturing process of the steel, with the restrictions given by the requirements in **6.2** to **6.4**, is left to the discretion of the manufacturer or as per agreement between manufacturer and purchaser.

6.2 All steels shall be killed. The steels not intended for heat treatment after cold forming (*see* Annex A) may be killed by aluminum or silicon or both. Case hardening grades (*see* Annex B) and quenching and tempering grades (*see* Annex C) shall be killed by aluminium.

6.3 Steel ingots with a minimum cross section area of 200 × 200 mm shall only be used and there should be sufficient reduction from ingot to final size of the product of the standard. For concast billets, a minimum reduction ratio 20:1 shall be used from cast billet to wire rod/wire/bar.

6.3.1 However, reduction ratio or ingot size other than mentioned in **6.3** may also be used subject to agreement between the supplier and the purchaser.

6.4 Suitable gas removal techniques at the steel making stage such as vacuum degassing, RH degassing etc may be adopted by the steel maker to control gas content and inclusion.

6.5 The material from either ingot or concast route shall be free from central segregation, looseness, dendritic structure, casting inhomogeneity, internal cracks, pipes and other harmful defects. If required, the permissible level of defects, as applicable, shall be agreed between supplier and the purchaser.

6.6 Traceability of the Cast

Each product shall be traceable to the cast, *see* **19.1**.

7 CHEMICAL COMPOSITION

7. 1 Ladle Analysis

The ladle analysis of steel, when carried out either by the methods specified in relevant parts of IS 228 or any other established international instrumental/chemical method, shall conform to the values in Tables A.2, B.2, C.2 and C.3. In case of any dispute, the procedure given in relevant parts of IS 228 shall be the referee method. Wherever test method is not covered under any part of IS 228, both method of testing and referee method shall be as agreed between manufacturer and purchaser.

In cases where steels for case hardening or for quenching and tempering are ordered with hardenability requirements in accordance with Tables B.6, B.7, C.9, C.10 and C.11, a deviation of the ladle analysis with respect to the values indicated in Tables B.2, C.2 and C.3 is admissible, taking into account the prescriptions given in footnote b of those tables. In any case, however, the deviations in the product analysis in relation to the specified limits of cast analysis shall not exceed the values indicated in Table 1.

7.2 Product Analysis

Permissible deviations between the limiting values for ladle analysis and the values for product analysis are given in Table 1.

Table 1 Permissible deviations between product analysis and the limiting values of the cast analysis specified in Tables A.2, B.2, C.2 and C.3

(*Clause* 7.2)

Sl No.	Elements	Limiting values of the ladle (heat) analysis	Permissible deviation for the product analysis
(1)	(2)	% mass fraction (3)	% mass fraction[a] (4)
For non-alloy and alloy steel grades of Annexes A, B and C			
i)	C	≤ 0.50	± 0.02
ii)	Si	≤ 1.00	± 0.03
iii)	Mn	≤ 1.00	± 0.04
		> 1.00 ≤ 2.00	± 0.05
iv)	P	≤ 0.025	+ 0.005
v)	S	≤ 0.040	+ 0.005[b]
vi)	Cr	≤ 2.00	± 0.05
		> 2.00 ≤ 5.00	± 0.10
vii)	Ni	≤ 1.00	±0.03
		> 1.00 ≤ 2.00	±0.05
		> 2.00 ≤ 5.00	± 0.07
viii)	Mo	≤ 0.30	±0.03
		> 0.30 ≤ 0.50	±0.04
ix)	Al	≤ 0.060	±0.005
x)	B	≤ 0.005 0	±0.0003
xi)	Cu	≤ 0.25	+0.03

[a] ± means that in one heat the deviation of the product analysis for a given element may occur over the upper value or under the lower value of the specified range of the ladle analysis, but not both at the same time.

[b] For steels with a specified sulphur range (0.020% to 0.035 or 0.040%) according to ladle analysis, the permissible deviation is ± 0.005%.

8 MECHANICAL PROPERTIES

8.1 The mechanical properties of the steel in condition of supply mentioned in Tables A.1, B.1 and C.1 shall conform to Tables A.3, A.4, B.3, B.4, B.5, B.8, C.4, C.5, C.6, C.7 and C.8.

8.1.1 The tensile test shall be carried out in accordance with IS 1608 (Part 1). The Brinell hardness test shall be carried out as per IS 1500 (Part 1). The tensile properties and hardness values, for cases not mentioned, may be mutually agreed between the purchaser and manufacturer.

8.2 Hardenability (only Applicable to Steel Grades of Annexes B and C)

8.2.1 Where the steel is not ordered with hardenability requirements, the requirements for mechanical properties apply as given in Tables B.3, B.4, B.5, B.8, C.4, C.5, C.6, C.7 and C.8. In this case, the hardenability values given in Tables B.6, B.7, C.9, C.10, C.11 are for guidance purposes only.

8.2.2 Method of testing for the end quench test (Jominy test) of steel shall be in accordance with IS 3848.

8.2.3 In the case of products ordered with standard requirements regarding hardenability, that is, when the steel names or numbers are supplemented by the symbol 'H', the hardness values obtained in the end quench test (Jominy test) shall conform to the values given in Tables B.6, C.9 and C.10.

In the case of products ordered with restricted requirements regarding the scatter bands of the hardness values obtained by the Jominy test, that is when the steel name or number is supplemented by the symbols 'HH' or 'HL', the above hardness values shall conform to the values given in Tables B.7 and C.11.

NOTES

1 The symbol 'HH' denotes that the upper limit of the scatter band coincides with the upper limit for the corresponding steel 'H'.

2 The symbol 'HL' denotes that the lower limit of the scatter band coincides with the lower limit for the corresponding steel 'H'.

3 For hardenability by calculation and for verification of hardenability, *see* **8.2.4** and **8.2.5**.

The austenitizing temperatures for the Jominy test are given in Tables B.6, B.7, C.9, C.10 and C.11.

8.2.4 In the case of steels for quenching and tempering (*see* Annex C) ordered with core hardening requirements, that is when the steel names or number are supplemented by the symbol 'CH', the minimum core hardness shall conform to the values given in Table C.12.

At least 90% of the structure shall be martensite.

8.2.5 *Verification of Hardenability*

As far as available, the manufacturer has the option to verify the hardenability by calculation. The calculation method is left to the discretion of the manufacturer. If agreed at the time of enquiry and order, the manufacturer shall give sufficient information about the calculation for the customer to confirm the result.

If a calculation formula is not available or in the case of dispute, an end quench hardenabilty test shall be carried out in accordance with IS 3848. The temperature for austenitizing shall conform to the relevant tables of Annexes B and C. The hardness values shall be determined in accordance with IS 1586 (Part 1), scale C.

8.2.6 *Verification of Core Hardness*

The test piece shall be heated in a furnace with a neutral or reducing atmosphere up to the temperatures indicated in Table C.12.

It shall be maintained at that temperature until complete austenitizing takes place. It shall then be removed from the furnace and quenched immediately in a quenching oil with high cooling capacity until a full equilibrium of temperature is reached, the temperature of the quenching bath being about 50°C and the rate of movement of the test piece being about 0.25 m/s. The test piece shall then be notched at its midpoint in a direction perpendicular to its longitudinal axis and then broken. One of the fracture surfaces shall be polished (care should be taken to prevent excessive local heating).

The Rockwell hardness at the centre of the fracture surface shall then be determined in accordance with IS 1586 (Part 1), scale C.

9 PREPARATION OF SAMPLES AND TEST PIECES

9.1 Selection and Preparation of Samples for Product Analysis

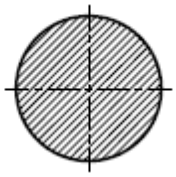
Samples for product analysis shall be taken from the test pieces or samples for mechanical testing or from the same location as the mechanical test samples in accordance with IS/ISO 14284.

If the product analysis is required by the purchaser, at least one sample product shall be taken from each cast/lot.

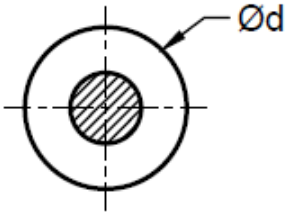
9.2 Selection and Preparation of Samples and Test Pieces for the Mechanical Tests

Samples and test pieces shall be taken in accordance with the general requirements of IS 3711. The test piece shall be prepared in accordance with IS 1608 Part 1.

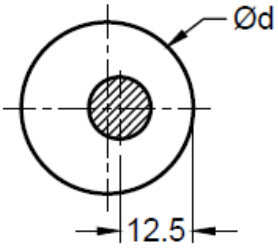
a) For products with d > 25 mm**:** The test piece for the tensile test shall be taken to conform to the indication given in Fig. 1 c).
b) For products with d > 50 mm**:** The test piece for the tensile test shall be taken to conform to the indication given in Fig. 1 d).
c) For products with d ≤ 25 mm: The test piece for the tensile test shall be submitted to test without preliminary machining, *see* Fig. 1 a). If test equipment does not allow this, the test piece may be prepared by machining, as shown in Fig. 1 b).
d) For hexagonal bars: The test piece for the tensile test shall be taken to conform to the indication given in Fig. A.7 of IS 3711.
e) For rectangular bars: The test piece for the tensile test shall be taken to conform to the indication given in Fig. A.8 of IS 3711.
f) For forms or sizes not covered in IS 3711, selection and preparation of samples and test pieces for the mechanical test may be mutually agreed between the purchaser and manufacturer.



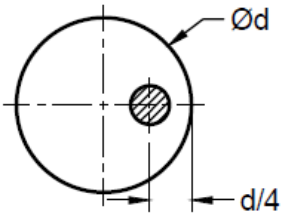
a) FULL SECTION TEST PIECE



b) ROUND TEST PIECE WHERE d ≤ 25 mm



c) ROUND TEST PIECE WHERE d > 25 mm



d) ROUND TEST PIECE WHERE d > 50 mm

FIG. 1 LOCATION OF TEST PIECE FOR THE TENSILE TEST

9.3 The test piece for the Jominy test (hardenability test) shall be obtained by machining from the samples with $d \leq 40$ mm. The samples shall be taken at the discretion of the manufacturer or as per agreement between manufacturer and purchaser either from the product concerned, or from the billet or bloom originating from the same cast. The sample shall be obtained by hot rolling or hot forging.

The test piece for evaluation of the core hardening test shall have, as far as possible, the maximum diameter indicated in Table C.12. Test bars with diameters larger than those given in Table C.12 are to be rolled or forged to the maximum diameters of Table C.12. Sampling and sample preparation is left to the manufacturer's discretion, taking into account the indications concerning the test piece for the end quench test (Jominy test). The length of the test piece shall be at least four times its diameter.

9.4 Sampling

9.4.1 For the purpose of this standard, products belonging to the same cast and same delivery condition shall constitute a lot. Samples shall be tested from each lot.

9.4.2 The ladle analysis shall be supplied by the producer. If a product analysis is required by the purchaser at least one sample of product shall be taken from each heat.

9.4.3 For determination of hardness, one sample of product shall be taken for each lot, subject to the minimum of at least two samples from each heat.

9.4.4 For mechanical tests, two test pieces shall be taken from each lot.

9.4.5 For Jominy test, one test piece shall be taken from each lot.

9.4.6 For other tests, the sampling method may be mutually agreed between the purchaser and manufacturer.

10 GRAIN SIZE

Steels of Annexes B and C shall have a fine grain structure with an austenite grain size number of 5 or finer. For verification, *see* **D.2**.

For steels of Annex A, the austenitic grain size may be as agreed to between the purchaser and the manufacturer.

The test for determining Austenitic grain size shall be carried out in accordance with IS 4748.

11 CARBIDE SPHEROIDIZATION

If carbide spheroidization is requested, reference shall be made to **D.3**.

12 NON-METALLIC INCLUSIONS

12.1 Microscopic Inclusions (only applicable for Steels of Annexes B and C)

If specifically agreed to between the purchaser and the manufacturer, *n*on-metallic inclusion test may be carried out.

12.1.1 Non-metallic inclusions when tested according to IS 4163 (Method A) shall not exceed the values given in Table 2. The worst field shall be recorded as a rating for the specimen.

Table 2 Requirements for the Microscopic Assessment of Content of Non-Metallic Inclusions
(*Clause* 12.1.1)

Sl No.	Inclusion Type	Thin		Thick	
	(2)	Worst	Mean	Worst	Mean
(1)		(3)	(4)	(5)	(6)
i)	A	4	2	3	1.5
ii)	B	3	2	2	1.0
iii)	C	4	2	3	1.5
iv)	D	3	2	2	1.0
v)	DS	-	-	2.5	1.0

NOTE – The method for assessment of non-metallic inclusions and the assessment criteria shall be by the 'worst field' method, as defined in IS 4163 (Method A) by using a severity rating of 0 to 5 (JK charts). The worst field for each individual inclusion type shall be recorded and a mean value calculated. Acceptance limits are shown above.

12.2 Macroscopic Inclusions

If verification is agreed, the method and acceptance limits shall be agreed at the time of enquiry and order.

13 APTITUDE TO COLD FORMING

A test for verification of the aptitude of products to cold forming may be carried out if agreed at the time of enquiry and order.

13.1 Upsetting Test

The surfaces of the end sections of the above test pieces shall be flat and parallel to each other and their initial length (height) shall be $h = 1.5*d$, where d is the test piece diameter. During the test, the length (height) of the test piece shall be reduced to one third of its initial value.

Supplementary for treated condition 'AC' and diameter less than 25 mm (d < 25 mm), the following may be agreed between the manufacturer and the customer. The surfaces of the end sections of the above test pieces shall be flat and parallel to each other and their initial length (height) shall be $h = 2.0*d$, where d is the test piece diameter. During the test, the length (height) of the test piece shall be reduced to one quarter of its initial value.

The tests shall be carried out at room temperature. The assessment and acceptance criteria shall also be agreed at time of enquiry and order.

NOTE – Hot-rolled surface grooves, which result from rolling scores, on test pieces are not considered as being a cause for rejection.

14 SURFACE QUALITY

14.1 General

All products shall have a smooth surface finish appropriate to the manufacturing process applied. For hot-rolled products, minor surface imperfections, which may occur also under normal manufacturing conditions, such as prints originating from rolled-in scale, are shall not be regarded as defects.

14.1.1 *Internal Soundness*

The material should be free from harmful microscopic defects like dendrities, blowholes, porosity, segregation, flakes, etc, which may impair the intended application of the material. A macro-etch test as per IS 13015 shall be performed to ensure freedom from such defects.

14.1.2 The steel shall be free from internal and surface defects likely to have an adverse effect during cold heading or subsequent heat treatment.

14.1.3 The bars, wire rods and wires may be normally subjected to any non-destructive test capable of revealing all the surface defects which would lead to rejection of the material on the basis of mutually agreed standard of acceptance.

14.1.3.1 The non-destructive test may consist of eddy current test in accordance with IS 13190 or magnetic particle test in accordance with IS 3703.

14.1.4 In the absence of any non-destructive test, adequate number of samples shall be tested by macro-etching/microscopic examination and the acceptance surface defects level shall be as given in Table 3:

Table 3 Depth of maximum allowable surface defect
(*Clause* 14.1.4)

Sl No.	Nominal Size mm	Defect Depth ***Max*** mm
(1)	(2)	(3)
i)	2 – 6	0.06
ii)	> 6 – 10	0.08
iii)	> 10 – 15	0.10
iv)	> 15 – 20	0.12
v)	> 20 – 30	0.15
vi)	> 30 and above	To be mutually agreed

14.2 Removal of Surface Defects

Removal of surface defects and imperfections may be considered if agreed to between the purchaser and the manufacturer.

14.3 Wire rod

Wire rod shall meet surface quality requirements in accordance with quality class 1 as given in Table 4. For certain higher applications, quality class 2 as given in Table 4 is appropriate and may be agreed at the time of enquiry and order.

14.4 Bars

Bars shall meet surface quality requirements in accordance with class 1 given in Table 4. Conformity to surface quality as given in quality class 2 of Table 4 may be agreed at the time of enquiry and order. When the diameter of the product is greater than the maximum diameter specified in Table 4 for the surface quality class concerned, the maximum permissible depth of surface defects on the product shall not be greater than that specified for this maximum diameter.

Table 4 Surface Quality Class
(*Clause* 14.4)

Class (1)	**Nominal Dimension[a],** d mm (2)	**Maximum Surface Depth of Surface Discontinuities[b],** mm (3)	**Portion Z (Default Value) %** (4)
1	$5 \leq d \leq 20$	0.15	0.5
	$20 < d \leq 40$	0.20	
	$40 < d \leq 100$	0.005*d*	
2	$5 \leq d \leq 100$	to be agreed, pdf[c]	0.2

[a] d is the nominal dimension that means diameter for rounds and distance across flats for squares and hexagons.

[b] The depth of surface discontinuities is measured from the actual surface of the product in radial direction. The dimensional tolerance shall also be considered when determining the section of the finished part which is ensured to be free of defect.

[c] pdf = practically defect free. This surface quality class shall be better than class 1. It is dependent upon the steel production process and its quality control because existing non-destructive inspection techniques cannot measure such minor discontinuities. The specific means of assuring this quality depend upon the customer's intended application and the requirements and the method of control shall be agreed upon between the parties.

14.5 Bright products

For wire, the permissible depth of surface discontinuities shall be in proportion to the reduction of the diameter during cold drawing. Depending on the starting material for cold drawn products, the same requirements apply as specified in **14.3**.

Cold drawn bars shall be delivered with the surface quality class 1 and peeled/turned bars shall be delivered with surface quality class 3 in accordance with Table 5.

Table 5 Surface quality Classes Surface Quality
(*Clause* 14.5)

Nominal Dimension[a], *d* mm		**Permissible Defect Depth,** *Max* mm
Over (1)	Up to and Including mm (2)	(3)
-	20	0.02
20	75	0.01*d*
75	-	0.75

15 DECARBURIZATION (only applicable for steels of Annexes B and C)

15.1 Bars and wire rod with as-rolled surface of steels specified in Table B.2, C.2 and C.3 and wire, independently of the heat treatment condition, shall be free from zones of complete decarburization.

15.2 Bars and wire rods processed in hot rolled condition and in annealed condition shall have partial decarburization as given in Table 6.

Table 6 Depth of maximum allowable partial decarburization
(*Clause* 15.2)

Sl No.	Nominal Size	Partial Decarburization Depth
(1)	(2)	(3)
i)	Up to and including 10 mm	0.07 mm, *Max*
ii)	Above 10.0 mm	0.70% of nominal size, *Max*

15.3 For cold drawn products with diameters greater than 5 mm, the limits of partial decarburization shall be the same as those for hot-rolled products. For cold drawn products with diameter less than 5 mm, the permissible depth of partial decarburization shall be reduced in function of the reduction of the diameter during the cold drawing. Peeled/turned bars, wire rod and wires shall be free of surface decarburization.

If, in special cases, the purchaser requests other values (example, bars annealed in an atmosphere that is, not controlled the depth of decarburization) for partial decarburization, those values shall be agreed at the time of enquiry and order with reference to **D.5**. Testing for decarburization should also be done according to **D.5**.

16 RETESTS

Retests shall be as specified in IS 8910.

17 SHAPE, DIMENSIONS AND TOLERANCES

17. 1 The tolerance and out-of-roundness of the bars/wire rods/wire shall be as follows:

Form	*Tolerance*	*Out-of-Roundness*
Bars	IS 3739	IS 3739
Wire rods up to 60 mm	IS/ISO 16124	IS/ISO 16124
Wire rods over 60 mm	as agreed to between the purchaser and the supplier	
Wire		

17.2 Bright bars shall be supplied as per the dimensions specified in the orders.

17.2.1 Tolerances on Bright Bars

Tolerances on dimensions of Diameter, Thickness and Width of bright bars shall be as specified by the purchaser and shall be in accordance with IS 919 (Part 2) as given in Table 7.

Table 7 Tolerance Class According to Finished Conditions
(*Clauses* 17.2.1)

Sl No.	Finished Condition	Tolerances Class to IS 919 (Part 2)						
		h6	h7	h8	h9	h10	h11	h12
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	Drawn				R	R	R,S,H	R,S,H
ii)	Turned				R	R	R	R
iii)	Turned and Reeled				R	R	R	R
iv)	Ground	R	R	R	R	R	R	R

R = round, S = square, H = hexagon

17.2.1.1 Unless specified otherwise, tolerances on dimensions shall be as follows:

a) For drawn round bars other than those under (e), or turned bars: h10 to Table 2.

b) For hexagonal and square drawn bars: h11 for dimensions up to and including 80 mm, h12 for dimensions over 80 mm according to Table 7 and 8.

c) For drawn flats: in accordance with Table 9 and 10.

d) For ground products: in accordance with Table 7 and 8.

e) For drawn round bars in the final quenched and tempered condition: h11.

17.2.2 *Length*

Bars and sections shall be supplied in length of 2.5 m to 4.5 m with maximum of 10 percent shorts of bot less than 1.5m. If bars of other lengths are required to be supplied the same shall be as per the mutual agreement between the purchaser and the manufacturer.

17.2.2.1 When bars are required in specific lengths, tolerance of + 5/-0 mm shall be applicable.

17.2.2.2 The ends of the bars shall be cut square without disturbing the dimensional tolerances.

Table 8 Tolerances Clauses
(*Clause* 17.2.1.1)

Nominal Dimensions		**Tolerances Class to IS 919 (Part 2)**						
Over	Up to and Including	h6	h7	h8	h9	h10	h11	h12
mm	mm							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
6	10	0.009	0.015	0.022	0.036	0.058	0.090	0.150
10	18	0.011	0.018	0.027	0.043	0.070	0.110	0.180
18	30	0.013	0.021	0.033	0.052	0.084	0.130	0.210
30	50	0.016	0.025	0.039	0.062	0.100	0.160	0.250
50	80	0.019	0.030	0.046	0.074	0.120	0.190	0.300
80	100	0.022	0.035	0.054	0.087	0.140	0.220	0.350

NOTE — The above deviation values are negatively disposed about the nominal dimension. For example, a 20 mm nominal diameter having a tolerance class h9 is 20, 0, -0.052 or 9.948/20.000 mm.

Table 9 Width Tolerance for Drawn Flats
(*Clause* 17.2.1.1)

Width		**Deviation**		**IS 919 (Part 2) Tolerance Class to**
Over	Up to and Including	Plus	Minus	
mm	mm	mm	mm	
(1)	(2)	(3)	(4)	(5)
–	18	0	0.11	h11
18	30	0	0.13	h11
30	50	0	0.16	h11
50	80	0	0.19	h11
80	100	0	0.22	h11
100	150	0.50	0.50	–
150	200	1.00	1.00	–
200	300	2.00	2.00	–
300	400	2.50	2.50	–

Table 10 Thickness Tolerance for Drawn Flats
(*Clause* 17.2.1.1)

Thickness		Deviation for Widths		IS 919 (Part 2) Tolerance Class to
Over	Up to and Including	Up to and Including 65	Over 65	
mm	mm	mm	mm	
(1)	(2)	(3)	(4)	(5)
3	6	-0.075	–	–
6	10	-0.090	-0.11	h11
10	18	-0.11	–	–
18	30	-0.13	-0.13	h11
30	50	-0.16	-0.16	h11
50	60	-0.19	-0.19	h11
60	80	-0.30	-0.30	h12
80	100	-0.35	-0.35	h12

NOTE — The above deviation values are negatively disposed.

17.2.3 *Straightness Tolerance*

17.2.3.1 Unless otherwise agreed, the permissible deviations shall not exceed 1.5 mm in any 1m length. The methods for evaluating straightness are given in Annex C for guidance.

17.2.3.2 Any other details regarding measuring and sampling method for straightness tolerance of bright bars shall be agreed upon at the time of inquiry and order.

17.2.4 *Out of Shape*

Maximum deviation from 'out of shape' shall be not more than half the specified tolerance.

17.2.5 *Edges of Non-Round Bars*

Non-round bars, that is, square, hexagon and flat in widths up to and including 150 mm shall have sharp corners without radius. For widths over 150 mm the corner profile may be undefined within a distance of 0.5 'mm of the hypothetical edge, unless sharp corners have specifically been ordered.

18 SURFACE TREATMENT

Surface treatment can facilitate subsequent cold heading and cold extrusion or partially delay any formation of rust. This treatment can include, for example descaling, treatment with lime and/or phosphate and/or adequate protection during transport and storage, and shall be subject to an agreement at the time of enquiry and order.

19 MARKING

19.1 Steel bars shall be suitably bundled and packed as per order. Each package of bars, coil of wire rods/wires shall carry a tag which shall be legibly marked with the cast number, grade, size and manufacturer's name or trademark. If mutually agreed, the weight of steel will be included in the tag. The colour code scheme as required by the purchaser may be adopted to mark the grade of the material. Further requirements to special marking of the products shall be agreed at the time of enquiry and order**.**

19.2 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the product(s) may be marked with the Standard Mark.

20 PACKAGING

Each coil of wire rod/wire shall be bound and fastened compactly. If required by the purchaser, a special method of packaging of the product to be delivered shall be agreed at the time of enquiry and order.

ANNEX A

SPECIFIC REQUIREMENTS FOR COLD HEADING AND COLD EXTRUDING STEELS NOT INTENDED FOR HEAT TREATMENT AFTER COLD WORKING

Table A.1 Combinations of Heat Treatments Conditions at Delivery, Product forms and Applicable Requirements
(*clauses* 4.2, 4.3, *and* 8.1)

Sl No.	Delivery condition		Symbols	Product form[a]			Applicable requirements		
				Wire Rod	Bar	Wire			
(1)	(2)		(3)	(4)	(5)	(6)	(7)		
i)	Untreated	(as hot-rolled)	+AR	X	X	—	Chemical composition as specified in Tables A.2	Mechanical properties as specified in Table A.3 and A.4	Supplementary or special requirements as specified in Annex D[b]
ii)	Untreated +	peeled	+AR+PE	X	X	—			
		cold drawn	+AR+C	—	X	X			
		cold drawn + spheroidized	+AR+C+AC	—	X	X			
		cold drawn + spheroidized + skin passed	+AR+C+AC+ LC	—	X	X			
iii)	Annealed to achieve spheroidized carbides +	as treated or peeled	+AC or AC+PE	X	X	—			
		cold drawn	+AC+C	—	X	X			
iv)	Other			Other delivery conditions may be agreed at the time of ordering					

[a] X = applicable, — = not applicable.

[b] If agreed at the time of enquiry and order.

Table A.2 Chemical Composition (applicable to Ladle Analysis) of Steels not intended for heat treatment after cold working
(*Clauses* 4.3 *and* 7.2)

Sl No.	Steel designation	Percent Mass Fraction[a]										
		C	Si	Mn	P	S	Cr	Ni	Mo	Al[b]	Cu	Cr + Ni + Mo
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Non-alloy steel grades												
i)	2C3	0.03	0.10	0.20 to 0.40c	0.020	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
ii)	4C3	0.02 to 0.06	0.10	0.25 to 0.40	0.020	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
iii)	8C3	0.06 to 0.10	0.10	0.25 to 0.45	0.020	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
iv)	4C2	0.08	e	0.40	0.035	0.035	0.15	0.15	0.05	e	0.15	d
v)	5C4	0.10	e	0.50	0.035	0.035	0.15	0.15	0.05	e	0.15	d
vi)	7C4	0.12	e	0.50	0.035	0.035	0.15	0.15	0.05	e	0.15	d
vii)	10C4C	0.08 to 0.12	0.10	0.30 to 0.50	0.025	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
viii)	10C4GC	0.08 to 0.12	0.15 to 0.25	0.30 to 0.50	0.025	0.025	0.30	0.30	0.10	0.015	0.30	0.50
ix)	10C4	0.15	e	0.30 to 0.60	0.035	0.035	0.15	0.15	0.05	e	0.15	d
x)	14C6	0.10 to 0.18	e	0.40 to 0.70	0.035	0.035	0.15	0.15	0.05	e	0.15	d
xi)	15C4C	0.13 to 0.17	0.10	0.35 to 0.60	0.025	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
xii)	15C4GC	0.13 to 0.17	0.15 to 0.25	0.35 to 0.60	0.025	0.025	0.30	0.30	0.10	0.015	0.30	0.50

Table A.2 (*concluded*)

xiii)	15C4	0.20	e	0.30 to 0.60	0.035	0.035	0.15	0.15	0.05	e	0.15	d
xiv)	15C8	0.10 to 0.20	e	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	e	0.15	d
xv)	17C8C	0.15 to 0.19	0.10	0.65 to 0.85	0.025	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
xvi)	17C8GC	0.15 to 0.19	0.15 to 0.25	0.65 to 0.85	0.025	0.025	0.30	0.30	0.10	0.015	0.30	0.50
xvii)	20C8C	0.18 to 0.22	0.10	0.70 to 0.90c	0.025	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
xviii)	20C8GC	0.18 to 0.22	0.15 to 0.25	0.70 to 0.90c	0.025	0.025	0.30	0.30	0.10	0.015	0.30	0.50
xix)	20C8	0.15 to 0.25	e	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	e	0.15	d
xx)	25C4	0.20 to 0.30	e	0.30 to 0.60	0.035	0.035	0.15	0.15	0.05	e	0.15	d
xxi)	25C8	0.20 to 0.30	e	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	e	0.15	d
xxii)	25C9C	0.23 to 0.27	0.10	0.80 to 1.00c	0.025	0.025	0.30	0.30	0.10	0.020 to 0.060	0.30	0.50
xxiii)	25C9GC	0.23 to 0.27	0.15 to 0.25	0.80 to 1.00c	0.025	0.025	0.30	0.30	0.10	0.015	0.30	0.50

Elements not quoted in this table should not be intentionally added to the steel without the agreement of the purchaser, except those intended for finishing the heat.

[a] Maximum values unless otherwise indicated.
[b] Aluminium may be replaced by another element or elements having a similar effect.
[c] For grades 2C3, 20C8C, 20C8GC, 25C9C and 25C9GC, a lower manganese content may be specified with a range of 0.20%.
[d] For these grades Sn=0.020% max and V=0.05% max and total of Cr, Ni, Cu, Sn, Mo and V shall not exceed 0.40%.
[e] When the steel is aluminium killed, the total aluminium content shall not be less than 0.02 percent.When the steel is silicon killed, the silicon content shall not be less than 0.10%. When the steel is aluminium silicon killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01%.

Table A.3 Mechanical properties of wire rod, bars and wire not intended for heat treatment after cold working
(*Clause* 8.1)

Sl No.	Steel designation	Diameter[c]		Delivery condition											
				+AR or +AR+PE		+AC or +AC+PE		+AR+C		+AR+C+AC		+AR+C+AC+LC		+AC+C	
		above	up to												
		mm	mm	**Rm** *Max* MPa	**Z**[a] *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	2C3	2[b]	5	—	—	—	—	—	—	310	80	350	75	—	—
		5	10	360	75	—	—	450	70	300	80	340	75	—	—
		10	40	360	75	—	—	440	70	300	80	340	75	—	—
		40	100	360	75	—	—	440	68	300	80	340	75	—	—
ii)	4C3	2[b]	5	—	—	—	—	—	—	320	77	360	73	—	—
		5	10	390	70	330	75	470	66	310	77	350	73	410	70
		10	40	390	70	330	75	460	66	300	77	350	73	400	70
		40	100	390	70	330	75	—	—	—	—	—	—	—	—
iii)	8C3	2[b]	5	—	—	—	—	—	—	350	72	390	68	—	—
		5	10	410	65	360	70	490	63	340	72	380	68	450	65
		10	40	410	65	360	70	480	63	340	72	380	68	440	65
		40	100	410	65	360	70	—	—	—	—	—	—	—	—
iv)	10C4C 10C4GC	2[b]	5	—	—	—	—	—	—	370	72	410	68	—	—
		5	10	430	60	380	70	520	58	360	72	400	68	470	63
		10	40	430	60	380	70	510	58	360	72	400	68	460	63
		40	100	430	60	380	70	—	—	—	—	—	—	—	—
v)	15C4C 15C4GC	2[b]	5	—	—	—	—	—	—	390	70	430	66	—	—
		5	10	460	58	400	68	550	56	380	70	420	66	490	63
		10	40	460	58	400	68	540	56	380	70	420	66	480	63
		40	100	460	58	400	68	—	—	—	—	—	—	—	—

Table A.3 (*concluded*)

Sl No.	Steel grade	Diameter[c]		Delivery Condition											
				+AR or +AR+PE		+AC or +AC+PE		+AR+C		+AR+C+AC		+AR+C+AC+LC		+AC+C	
		above mm	up to mm	**Rm** *Max* MPa	**Z**[a] *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %
vi)	17C8C 17C8GC	2[b]	5	—	—	—	—	—	—	430	67	470	63	—	—
		5	10	520	58	440	65	610	56	420	67	460	63	530	60
		10	40	520	58	440	65	600	56	420	67	460	63	520	60
		40	100	520	58	440	65	—	—	—	—	—	—	—	—
vii)	20C8C 20C8GC	2[b]	5	—	—	—	—	—	—	470	67	510	63	—	—
		5	10	560	55	480	65	650	53	460	67	500	63	570	60
		10	40	560	55	480	65	640	53	460	67	500	63	560	60
		40	100	560	55	480	65	—	—	—	—	—	—	—	—
viii)	25C9C	2[b]	5	—	—	—	—	—	—	500	65	540	60	—	—
		5	10	590	50	510	60	680	50	490	65	530	60	600	55
		10	40	590	50	510	60	670	50	490	65	530	60	590	55
		40	100	590	50	510	60	—	—	—	—	—	—	—	—
ix)	25C9GC	2[b]	5	—	—	—	—	570	45	—	—	440	55	—	—
		5	10	590	50	—	—	470	45	—	—	440	55	440	55
		10	40	590	50	—	—	470	45	—	—	440	55	440	55
		40	100	590	50	—	—	—	—	—	—	—	—	—	—

[a] The values are given only for information
[b] Including 2 mm
[c] For non-circular cross-section, properties may be as agreed to between manufacturer and purchaser.

Table A.4 Maximum Hardness for Products Delivered in Annealed Condition (+AC)
(*Clause* 8.1)

Sl No. (1)	**Steel designation** (2)	**Brinell Hardness** *Max* HBW (3)
i)	4C2	120
ii)	5C4	120
iii)	7C4	120
iv)	10C4	130
v)	14C6	140
vi)	15C4	140
vii)	15C8	140
viii)	20C8	150
ix)	25C4	150
x)	25C8	150

ANNEX B

SPECIFC REQUIREMENTS FOR COLD HEADING AND COLD EXTRUDING CASE-HARDENING STEELS

Table B.1 Combinations of Heat Treatments Conditions at Delivery, Product forms and Applicable Requirements
(*Clauses* 4.2 *and* 8.1)

Sl No.	**Heat-treatment condition at delivery**	**Symbol**	**Products form[a]**			**Applicable requirements in cases where the steel concerned has been ordered with reference to the steel grades indicated in**					
			Wire rod	Bar	Wire	Tables B.2, B.3, B.4 , B.5 or B.8		Tables B.2, B.3, B.4, B.5, B.6 , B.7 or B.8			Optional
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	As hot-rolled or peeled	+AR or +PE	X	X	X	Chemical composition as specified in Tables B.2	Mechanical properties as specified in Table B.3, B.4, B.5, B.8	Chemical composition as specified in Table B.2	Mechanical properties as specified in Tables B.3, B.4,B.5 and B.8	Values for hardenability according to Tables B.6 and B.7	Supplementary or special requirements as specified in Annex D[b]
ii)	Cold drawn	+AR +C	—	x	X						
iii)	Cold drawn + Spheroidized	+AR +C +AC	—	x	X						
iv)	Cold drawn + spheroidized + skin passed	+AR +C +AC + LC	—	x	x						
v)	Spheroidized or spheroidized + peeled	+AC or +AC +PE	X	X	X						
vi)	Spheroidized + cold drawn	+AC + C	—	x	X						
vii)	Treated to ferrite- pearlite structure and hardness range	+FP	—	X	—						
viii)	Others	Other delivery conditions may be agreed at the time of ordering									

[a] X = applicable, — = not applicable.

[b] If agreed at the time of the enquiry and order.

Table B.2 Chemical Composition (Applicable to Ladle Analysis) of Steels for Case Hardening
(*Clauses* 4.3,7.1 and 15.1)

Sl No.	Steel designation[b]	Percent Mass Fraction[a]									
		C	Si	Mn	P	S	Cr	Ni	Mo	B	Cu
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Non-alloy steel grades											
i)	10C4	0.15	0.05 to 0.35	0.30 to 0.60	0.035	0.035	0.15	0.15	0.05	—	0.15c
ii)	10C4GC	0.08 to 0.12	0.30	0.30 to 0.60	0.025	0.025	—	—	—	—	0.25
iii)	11C15	0.16	0.10 to 0.35	1.30 to 1.70	0.035	0.035	0.15	0.15	0.05	—	0.15c
iv)	14C6	0.10 to 0.18	0.05 to 0.35	0.40 to 0.70	0.035	0.035	0.15	0.15	0.05	—	0.15c
v)	15C4GC	0.13 to 0.17	0.30	0.30 to 0.60	0.025	0.025	—	—	—	—	0.25
vi)	15C8	0.10 to 0.20	0.10 to 0.35	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	—	0.15c
vii)	17C8GC	0.15 to 0.19	0.30	0.60 to 0.90	0.025	0.025	—	—	—	—	0.25
viii)	20C4GC	0.18 to 0.22	0.30	0.30 to 0.60	0.025	0.025	—	—	—	—	0.25
Alloy steel grades											
ix)	18C10BT	0.16 to 0.20	0.30	0.90 to 1.20	0.025	0.025	—	—	—	0.000 8 to 0.005	0.25
x)	22C10BT	0.20 to 0.24	0.30	0.90 to 1.20	0.025	0.025	—	—	—	0.000 8 to 0.005	0.25
xi)	20C10BT	0.17 to 0.24	0.40	0.80 to 1.15	0.035	0.035	—	—	—	0.000 8 to 0.005	-
xii)	16Cr4	0.12 to 0.20	0.30	0.60 to 0.90	0.025	0.025	0.70 to 1.25	—	—	—	0.25
xiii)	16Cr4S3	0.12 to 0.20	0.30	0.60 to 0.90	0.025	0.020 to 0.040	0.70 to 1.25	—	—	—	0.25
xiv)	20Cr4	0.17 to 0.23	0.30	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	—	—	0.25
xv)	20Cr4S3	0.17 to	0.30	0.60 to 0.90	0.025	0.020 to 0.040	0.90 to 1.20	—	—	—	0.25

Table B.2 (*Continued*)

		0.23									
xvi)	16Mn5Cr4	0.14 to 0.19	0.10 to 0.35	1.00 to 1.30	0.035	0.035	0.80 to 1.10	0.15	0.05	—	0.15c
xvii)	16Mn5Cr5	0.14 to 0.19	0.30	1.00 to 1.30	0.025	0.025	0.80 to 1.10	—	—	—	0.25
xviii)	16Mn5Cr5S3	0.14 to 0.19	0.30	1.00 to 1.30	0.025	0.020 to 0.040	0.80 to 1.10	—	—	—	0.25
xix)	16Mn5Cr5BT	0.14 to 0.19	0.30	1.00 to 1.30	0.025	0.025	0.80 to 1.10	—	—	0.000 8 to 0.005	0.25
xx)	20Mn5Cr5	0.17 to 0.22	0.10 to 0.35	1.00 to 1.40	0.035	0.035	1.00 to 1.30	0.15	0.05	—	0.15c
xxi)	20Mn5Cr5S3	0.17 to 0.22	0.30	1.10 to 1.40	0.025	0.020 to 0.040	1.00 to 1.30	—	—	—	0.25
xxii)	12Cr4Mo2	0.10 to 0.15	0.30	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	0.15 to 0.25	—	0.25
Sl No.	**Steel Designation[b]**	**Percent Mass Fraction[a]**									
(1)	(2)	**C** (3)	**Si** (4)	**Mn** (5)	**P** (6)	**S** (7)	**Cr** (8)	**Ni** (9)	**Mo** (10)	**B** (11)	**Cu** (12)
xxiii)	18Cr4Mo2	0.15 to 0.21	0.30	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	0.15 to 0.25	—	0.25
xxiv)	18Cr4Mo2S3	0.15 to 0.21	0.30	0.60 to 0.90	0.025	0.020 to 0.040	0.90 to 1.20	—	0.15 to 0.25	—	0.25
xxv)	20Mo5Cr2	0.17 to 0.23	0.30	0.70 to 1.00	0.025	0.025	0.30 to 0.60	—	0.40 to 0.50	—	0.25
xxvi)	20Mo5Cr2S3	0.17 to 0.23	0.30	0.70 to 1.00	0.025	0.020 to 0.040	0.30 to 0.60	—	0.40 to 0.50	—	0.25
xxvii)	10Ni5Cr4	0.07 to 0.12	0.30	0.60 to 0.90	0.025	0.025	0.90 to 1.20	1.20 to 1.50	—	—	0.25
xxviii)	12Ni3Cr2	0.09 to 0.15	0.30	0.30 to 0.60	0.025	0.025	0.40 to 0.70	0.50 to 0.80	—	—	0.25
xxix)	17Ni6Cr6	0.14 to 0.20	0.30	0.50 to 0.90	0.025	0.025	1.40 to 1.70	1.40 to 1.70	—	—	0.25
xxx)	20Ni2Cr2Mo2	0.17-0.23	0.15 to 0.35	0.65 to 0.95	0.025	0.025	0.35 to 0.70	0.40 to 0.70	0.15 to 0.25	—	0.25
xxxi)	20Ni2Cr2Mo2S3	0.17 to 0.23	0.30	0.65 to 0.95	0.025	0.020 to 0.040	0.35 to 0.70	0.40 to 0.70	0.15 to 0.25	—	0.25

Table B.2 (*Concluded*)

xxxii)	20Ni8Cr2Mo3	0.17 to 0.23	0.30	0.40 to 0.70	0.025	0.025	0.35 to 0.65	1.60 to 2.00	0.20 to 0.30	—	0.25
xxxiii)	20Ni6Cr3Mo3S3	0.16 to 0.23	0.30	0.50 to 0.90	0.025	0.020 to 0.040	0.60 to 0.90	1.40 to 1.70	0.25 to 0.35	—	0.25
xxxiv)	20Ni7Mo2	0.17 to 0.22	0.10 to 0.35	0.45 to 0.70	0.035	0.035	0.15	1.65 to 2.00	0.20 to 0.30	—	0.15c
xxxv)	15Cr3	0.12 to 0.18	0.10 to 0.35	0.40 to 0.60	0.035	0.035	0.50 to 0.80	0.15	0.05	—	0.15c
xxxvi)	16Ni3Cr2	0.12 to 0.20	0.10 to 0.35	0.60 to 1.00	0.035	0.035	0.40 to 0.80	0.60 to 1.00	0.05	—	0.15c
xxxvii)	16Ni4Cr3	0.12 to 0.20	0.10 to 0.35	0.60 to 1.00	0.035	0.035	0.60 to 1.00	0.80 to 1.20	0.05	—	0.15c
xxxviii)	13Ni14Cr3	0.10 to 0.15	0.10 to 0.35	0.40 to 0.70	0.035	0.035	0.60 to 1.00	3.00 to 3.50	0.05	—	0.15c
xxxix)	15Ni5Cr5	0.12 to 0.18	0.10 to 0.35	0.40 to 0.70	0.035	0.035	1.00 to 1.40	3.80 to 4.30	0.05	—	0.15c
xl)	20NiCrMo2	0.18 to 0.23	0.10 to 0.35	0.70 to 0.90	0.035	0.035	0.40 to 0.60	0.40 to 0.70	0.15 to 0.25	—	0.15c
xli)	15Ni5Cr4Mo1	0.12 to 0.18	0.10-0.35	0.60 to 1.00	0.035	0.035	0.75 to 1.25	1.00 to 1.50	0.08 to 0.15	—	0.15c
xlii)	15Ni7Cr4Mo2	0.12 to 0.18	0.10-0.35	0.60 to 1.00	0.035	0.035	0.75 to 1.25	1.50 to 2.00	0.10 to 0.20	—	0.15c
xliii)	16Ni8Cr6Mo2	0.12 to 0.20	0.10-0.35	0.40 to 0.70	0.035	0.035	1.40 to 1.70	1.80 to 2.20	0.15 to 0.25	—	0.15c
xliv)	17Ni2Cr2Mo2	0.15 to 0.20	0.15 to 0.35e	0.70 to 0.90	0.030	0.040	0.40 to 0.60	0.40 to 0.70	0.15 to 0.25	—	0.35
xlv)	21Ni2Cr2Mo2	0.18 to 0.23	0.15 to 0.35e	0.70 to 0.90	0.030	0.040	0.40 to 0.60	0.40 to 0.70	0.15 to 0.25	—	0.35
xlvi)	20Ni2Cr2Mo3	0.18 to 0.23	0.15 to 0.35e	0.70 to 0.90	0.030	0.040	0.40 to 0.60	0.40 to 0.70	0.20 to 0.30	—	0.35

Elements not quoted in this table should not be intentionally added to the steel without the agreement of the purchaser, except those intended for finishing the heat.

[a] Maximum values unless otherwise indicated.

[b] In the case of steels with hardenability requirements (*see* Tables B.6 and B.7), minor deviations from the specified limits are permitted (with the exception of sulphur and phosphorus), provided that they do not exceed 0.01% for carbon and the values indicated in Table 1 for the other elements. However, the limits for product analysis for such cases to be considered against the values given in Table B.2.

[c] For these grades Sn = 0.020% *Max* and V = 0.05% *Max* and total of Cr, Ni, Cu, Sn, Mo and V shall not exceed 0.40%, wherever not applicable as an alloying element.

[d] As agreed to between manufacturer and purchaser.

[e] Other silicon ranges are permitted when agreed by purchaser and supplier.

Table B.3 Mechanical Properties of Non-Alloy Steel Grades
(*Clauses* 8.1 *and* 8.2.1)

Sl No.	Steel designation	Diameter[c]		Delivery condition											
				+AR or +PE		+AC or +AC+PE		+AR+C		+AR+C+AC		+AR+C+AC+LC		+AC+C	
		above	up to	**Rm** *Max* MPa	**Z**[a] *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %
(1)	(2)	mm (3)	mm (4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	10C4GC	2[b]	5	—	—	—	—	—	—	390	67	430	65	—	—
		5	10	450	58	400	65	540	56	380	67	420	65	490	62
		10	40	450	58	400	65	530	56	380	67	420	65	480	62
		40	100	450	58	400	65	—	—	—	—	—	—	—	—
ii)	15C4GC	2[b]	5	—	—	—	—	—	—	420	67	460	65	—	—
		5	10	480	58	430	65	570	56	410	67	450	65	520	62
		10	40	480	58	430	65	560	56	410	67	450	65	510	62
		40	100	480	58	430	65	—	—	—	—	—	—	—	—
iii)	17C8GC	2[b]	5	—	—	—	—	—	—	440	67	480	65	—	—
		5	10	530	58	450	65	630	56	430	67	470	65	550	62
		10	40	530	58	450	65	620	56	430	67	470	65	540	62
		40	100	530	58	450	65	—	—	—	—	—	—	—	—
iv)	20C4GC	2[b]	5	—	—	—	—	—	—	460	67	500	65	—	—
		5	10	530	58	470	65	640	56	450	67	490	65	580	62
		10	40	530	58	470	65	630	56	450	67	490	65	570	62
		40	100	530	58	470	65	—	—	—	—	—	—	—	—

[a] The values are given only for information.
[b] Including 2 mm.
[c] For non-circular cross-section, properties may be as agreed to between manufacturer and purchaser.

Table B.4 Mechanical Properties of Boron-Alloyed Steel Grades
(*Clause* 8.1 *and* 8.2.1)

Sl No.	Steel designation	Diameter[c]		Delivery condition											
				+AR		+AC or +AC+PE		+AR+C		+AR+C+AC		+AR+C+AC+LC		+AC +C	
		above mm	up to mm	**Rm** *Max* MPa	**Z**[a] *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	18C10BT	2[b]	5	—	—	—	—	—	—	500	64	540	62	—	—
		5	10	580	55	500	64	680	53	480	64	520	62	600	59
		10	40	580	55	500	64	670	53	480	64	520	62	590	59
ii)	22C10BT	2[b]	5	—	—	—	—	—	—	520	64	560	62	—	—
		5	10	600	55	520	62	720	53	500	64	540	62	630	59
		10	40	600	55	520	62	710	53	500	64	540	62	620	59

[a] The values are given only for information.
[b] Including 2 mm.
[c] For non-circular cross-section, properties may be as agreed to between manufacturer and purchaser.

Table B.5 Mechanical Properties of Alloyed Steel Grades
(*Clauses* 8.1 *and* 8.2.1)

Sl No.	Steel designation	Diameter[b]		Delivery condition									
				+AC		+FP		+AR+C+AC		+AR+C+AC+LC		+AC+C	
				Mechanical properties									
		above	up to	Rm	Z	HB		Rm	Z	Rm	Z	Rm	Z
				Max	*Min*	*Min*	*Max*	*Max*	*Min*	*Max*	*Max*	*Max*	*Max*
		mm	mm	MPa	%			MPa	%	MPa	%	MPa	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
i)	16Cr4 16Cr4S3	2 [a]	5	—	—	—	—	520	62	560	60	—	—
		5	10	520	60	140	187	500	62	540	60	630	57
		10	40	520	60	140	187	500	62	540	60	620	57
ii)	20Cr4 20Cr4S3	2 [a]	5	—	—	—	—	—	—	—	—	—	—
		5	10	—	—	—	—	540	60	580	60	640	55
		10	40	640	60	—	—	540	60	580	60	640	55
iii)	16Mn5Cr5 16Mn5Cr5S3 16Mn5Cr5BT	2 [a]	5	—	—	—	—	550	64	590	62	—	—
		5	10	550	62	140	187	530	64	570	62	660	59
		10	40	550	62	140	187	530	64	570	62	650	59
iv)	20Mn5Cr5S3	2 [a]	5	—	—	—	—	570	62	610	60	—	—
		5	10	570	60	152	201	550	62	590	60	680	57
		10	40	570	60	152	201	550	62	590	60	670	57
v)	12Cr4Mo2	2[a]	5	—	—	—	—	500	—	—	—	—	—
		5	10	500	62	135	185	480	64	520	62	—	—
		10	40	500	62	135	185	480	64	520	62	—	—
vi)	18Cr4Mo2 18Cr4Mo2S3	2[a]	5	—	—	—	—	550	62	590	60	—	—
		5	10	550	60	140	187	530	62	570	60	660	57
		10	40	550	60	140	187	530	62	570	60	650	57
vii)	20Mo5Cr2	2[a]	5	—	—	—	—	560	62	600	60	—	—
		5	10	560	60	140	187	540	62	580	60	670	57

Table B.5 (*Concluded*)

	20Mo5Cr2S3	10	40	560	60	140	187	540	62	580	60	660	57
viii)	10Ni5Cr4	2[a]	5	—	—	—	—	520	64	560	62	—	—
		5	10	520	62	137	187	500	64	540	62	640	59
		10	40	520	62	137	187	500	64	540	62	630	59
ix)	12Ni3Cr2	2[a]	5	—	—	—	—	500	64	540	62	—	—
		5	10	500	62	130	180	480	64	520	62	620	59
		10	40	500	62	130	180	480	64	520	62	610	59
x)	17Ni6Cr6	2[a]	5	—	—	—	—	600	62	640	60	—	—
		5	10	600	60	156	207	580	62	620	60	720	57
		10	40	600	60	156	207	580	62	620	60	710	57
xi)	20Ni2Cr2Mo2 20Ni2Cr2Mo2S3	2[a]	5	—	—	—	—	590	62	630	60	—	—
		5	10	590	60	149	194	570	62	610	60	720	57
		10	40	590	60	149	194	570	62	610	60	710	57
	20Ni8Cr2Mo3	2[a]	5	—	—	—	—	—	—	—	—	—	—
xii)		5	10	—	—	—	—	680	60	—	—	700	55
		10	25	—	—	—	—	680	60	—	—	700	55
	20Ni6Cr3Mo3S3	2[a]	5	—	—	—	—	610	60	650	58	—	—
xiii)		5	10	610	58	149	201	590	60	630	58	730	55
		10	25	610	58	149	201	590	60	630	58	720	55

[a] Including 2 mm.

[b] For non-circular cross-section, properties may be as agreed to between manufacturer and purchaser.

Table B.6 Hardness Limits for Steel Grades with Standard Hardenability (H Grades)
(*Clauses* 7.1, 8.2.1 *and* 8.2.3)

Sl No.	Steel designation	Symbol	Austenitizing temperature °C ± 5°C	Limits of range	Hardness HRC at a distance from quenched end of test piece (in mm) of												
					1.5	3	5	7	9	11	13	15	20	25	30	35	40
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
i)	18C10BT	H	890	*Max*	46	45	44	41	39	35	32	28	21	—	—	—	—
				Min	40	38	37	30	21	—	—	—	—	—	—	—	—
ii)	22C10BT	H	880	*Max*	49	48	47	45	42	39	35	32	24	20	—	—	—
				Min	43	41	40	32	23	—	—	—	—	—	—	—	—
iii)	16Cr4 16Cr4S3	H	880	*Max*	47	44	40	33	29	27	25	24	23	21	—	—	—
				Min	39	35	25	20	—	—	—	—	—	—	—	—	—
iv)	20Cr4 20Cr4S3	H	900	*Max*	49	48	46	42	38	36	34	32	29	27	26	24	23
				Min	41	38	31	26	23	21	—	—	—	—	—	—	—
v)	16Mn5Cr5 16Mn5Cr5S3	H	870	*Max*	47	46	44	41	39	37	35	33	31	30	29	28	27
				Min	39	36	31	28	24	21	—	—	—	—	—	—	—
vi)	16Mn5Cr5BT	H	870	*Max*	47	46	44	41	39	37	35	33	31	30	29	28	27
				Min	39	36	31	28	24	21	—	—	—	—	—	—	—
vii)	20Mn5Cr5S3	H	870	*Max*	49	49	48	46	43	42	41	39	37	35	34	33	32
				Min	41	39	36	33	30	28	26	25	23	21	—	—	—
viii)	12Cr4Mo2	H	870	*Max*	44	43	41	38	34	30	28	27	23	21	—	—	—
				Min	36	34	30	26	22	—	—	—	—	—	—	—	—
ix)	18Cr4Mo2 18Cr4Mo2S3	H	880	*Max*	47	46	45	42	39	37	35	34	31	29	28	27	26
				Min	39	37	34	30	27	24	22	21	—	—	—	—	—
x)	20Mo5Cr2 20Mo5Cr2S3	H	910	*Max*	49	47	44	41	38	35	33	31	28	26	25	24	24
				Min	41	37	31	27	24	22	—	—	—	—	—	—	—
xi)	10Ni5Cr4	H	880	*Max*	41	39	37	34	32	30	—	—	—	—	—	—	—
				Min	32	27	24	22	—	—	—	—	—	—	—	—	—
xii)	12Ni3Cr2	H	870	*Max*	43	40	35	26	21	—	—	—	—	—	—	—	—
				Min	37	32	25	—	—	—	—	—	—	—	—	—	—

Table B.6 (*Continued*)

xiii)	17Ni6Cr6	H	870	*Max*	47	47	46	45	43	42	41	39	37	35	34	34	33
				Min	39	38	36	35	32	30	28	26	24	22	21	20	20
xiv)	20Ni2Cr2Mo2 20Ni2Cr2Mo2S 3	H	880	*Max*	49	48	45	42	36	33	31	30	27	25	24	24	23
				Min	41	37	31	25	22	20	—	—	—	—	—	—	—
xv)	20Ni8Cr2Mo3	H	900	*Max*	48	47	45	42	39	36	34	32	29	26	25	24	24
				Min	40	38	34	30	27	25	23	22	20	—	—	—	—
xvi)	20Ni6Cr3Mo3S 3	H	880	*Max*	49	49	48	48	47	47	46	44	41	39	38	37	36
				Min	41	40	39	36	33	30	28	26	23	21	—	—	—

Table B.6 (*Concluded*)

Sl No.	**Steel designation**	**Symbol**	**Austenitizing temperature** °C ± 5°C	**Limits of range**	**Hardness HRC at a distance from quenched end of test piece (in 25.4/16 mm) of**																						
					1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
xvii)	21Ni2Cr2Mo2	H	860	*Max*	48	47	44	41	37	34	32	30	29	28	27	26	25	25	24	24	23	23	23	23	23	22	22	22
				Min	41	37	32	27	23	21	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
xviii)	17Ni2Cr2Mo2	H	860	*Max*	46	44	41	38	34	31	28	27	26	25	24	23	23	22	22	21	21	20	—	—	—	—	—	—
				Min	39	33	27	24	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
xix)	20Ni2Cr2Mo3	H	860	*Max*	48	47	45	42	38	35	33	31	30	29	28	27	26	26	25	25	24	24	23	23	23	23	22	22
				Min	41	38	35	30	26	24	22	21	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table B.7 Hardness Limits for Steel Grades with Restricted Hardenability Scatter Bands (HH and HL Grades)
(*Clauses* 7.1, 8.2.1 *and* 8.2.3)

Sl No.	Steel grades	Symbol	Austenitizing temperature °C ± 5°C	Limits of range	Hardness HRC at a distance from quenched end of test piece (in mm) of												
					1.5	3	5	7	9	11	13	15	20	25	30	35	40
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
i)	16Cr4 16Cr4S3	HH	880	*Max*	47	44	40	33	29	27	25	24	23	21	—	—	—
				Min	42	38	30	24	20	—	—	—	—	—	—	—	—
		HL		*Max*	44	41	35	29	25	23	21	20	—	—	—	—	—
				Min	39	35	25	20	—	—	—	—	—	—	—	—	—
ii)	20Cr4 20Cr4S3	HH	900	*Max*	49	48	46	42	38	36	34	32	29	27	26	24	23
				Min	44	41	36	31	28	26	24	22	—	—	—	—	—
		HL		*Max*	46	45	41	37	33	31	29	27	24	22	21	—	—
				Min	41	38	31	26	23	21-	—	—	—	—	—	—	—
iii)	16Mn5Cr5 16Mn5Cr5S3	HH	870	*Max*	47	46	44	41	39	37	35	33	31	30	29	28	27
				Min	42	39	35	32	29	26	24	22	20	—	—	—	—
		HL		*Max*	44	43	40	37	34	32	30	28	26	25	24	23	22
				Min	39	36	31	28	24	21	—	—	—	—	—	—	—
iv)	16Mn5Cr5BT	HH	870	*Max*	47	46	44	41	39	37	35	33	31	30	29	28	27
				Min	42	39	35	32	29	26	24	22	20	—	—	—	—
		HL		*Max*	44	43	40	37	34	32	30	28	26	25	24	23	22
				Min	39	36	31	28	24	21	—	—	—	—	—	—	—
v)	20Mn5Cr5S3	HH	870	*Max*	49	49	48	46	43	42	41	39	37	35	34	33	32
				Min	44	42	40	37	34	33	31	30	28	26	25	24	23
		HL		*Max*	46	46	44	42	39	37	36	34	32	30	29	28	27
				Min	41	39	36	33	30	28	26	25	23	21	—	—	—
vi)	12Cr4Mo2	HH	870	*Max*	44	43	41	38	34	30	28	27	23	21	—	—	—
				Min	39	37	34	30	26	21	—	—	—	—	—	—	—
		HL		*Max*	41	40	37	34	30	26	23	20	—	—	—	—	—
				Min	36	34	30	26	22	—	—	—	—	—	—	—	—

Table B.7 (*concluded*)

vii)	18Cr4Mo2 18Cr4Mo2S3	HH	880	*Max*	47	46	45	42	39	37	35	34	31	29	28	27	26
				Min	42	40	38	34	31	28	26	25	22	20	—	—	—
		HL		*Max*	44	43	41	38	35	33	31	30	27	25	24	23	22
				Min	39	37	34	30	27	24	22	21	—	—	—	—	—
viii)	20Mo5Cr2 20Mo5Cr2S3	HH	910	*Max*	49	47	44	41	38	35	33	31	28	26	25	24	24
				Min	44	40	35	32	29	26	24	22	—	—	—	—	—
		HL		*Max*	46	44	40	36	33	31	29	27	24	22	21	20	20
				Min	41	37	31	27	24	22	—	—	—	—	—	—	—
ix)	10Ni5Cr4	HH	880	*Max*	41	39	37	34	32	30	—	—	—	—	—	—	—
				Min	33	29	26	24	21	20	—	—	—	—	—	—	—
		HL		*Max*	38	35	32	30	27	25	—	—	—	—	—	—	—
				Min	32	27	24	22	—	—	—	—	—	—	—	—	—
x)	17Ni6Cr6	HH	870	*Max*	47	47	46	45	43	42	41	39	37	35	34	34	33
				Min	42	41	39	38	36	34	32	30	28	26	25	25	24
		HL		*Max*	44	44	43	42	39	38	37	35	33	31	30	29	29
				Min	39	38	36	35	32	30	28	26	24	22	21	20	20
xi)	20Ni2Cr2Mo2 20Ni2Cr2Mo2 S3	HH	880	*Max*	49	48	45	42	36	33	31	30	27	25	24	24	23
				Min	44	41	36	31	27	24	22	21	—	—	—	—	—
		HL		*Max*	46	44	40	36	31	29	27	26	23	21	20	20	—
				Min	41	37	31	25	22	20	—	—	—	—	—	—	—
xii)	20Ni6Cr3Mo3 S3	HH	880	*Max*	49	49	48	48	47	47	46	44	41	39	38	37	36
				Min	44	43	42	40	38	36	34	32	29	27	26	25	24
		HL		*Max*	46	46	45	44	42	41	40	38	35	33	32	31	30
				Min	41	40	39	36	33	30	28	26	23	21	—	—	—

Table B.8 Maximum Hardness for Products Delivered in Annealed Condition (+AC)

(*Clauses* 8.2 *and* 8.2.1)

Sl No. (1)	**Steel designation** (2)	**Brinell hardness**, *Max* HBW (3)
i)	10C4	130
ii)	14C6	140
iii)	15C8	140
iv)	20NiCrMo2	180
v)	20Ni7Mo2	180
vi)	11C15	170
vii)	15Cr3	140
viii)	16Mn5Cr4	160
ix)	20Mn5Cr4	170
x)	16Ni3Cr2	160
xi)	16Ni4Cr3	180
xii)	13Ni14Cr3	190
xiii)	15Ni5Cr5	200
xiv)	15Ni5Cr4Mo1	180
xv)	15Ni7Cr4Mo2	180
xvi)	16Ni8Cr6Mo2	190

ANNEX C
SPECIFIC REQUIREMENTS FOR COLD HEADING AND COLD EXTRUDING STEELS FOR QUENCHING AND TEMPERING

Table C.1 Combinations of Heat Treatment Conditions at Delivery, Product forms and Applicable Requirements
(*Clauses* 4.2, 4.3 *and* 8.1)

Sl No.	Heat-treatment condition at delivery	Symbol	Products forma			Applicable requirements in cases where the steel concerned has been ordered with reference to the steel grades indicated in								
			Wire rod	Bar	Wire	Tables C.2, C.3, C.4, C.5, C.6, C.7, C.8		Tables C.2, C.3, C.4, C.5, C.6, C.7, C.8, C.9, C10, C11			Tables C.2, C.3, C.4, C.5, C.6, C7, C8, C12			Optional
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	As hot-rolled or peeled	+AR or +PE	X	X	x	Chemical compo-sition as specified in Tables C.2 and C.3	Mechanical proper-ties as specified in Tables C.4, C.5, C.6, C.7 and C.8	Chemical compo-sition as specified in Tables C.2 and C.3	Mechanical proper-ties as specified in Tables C.4, C.5, C.6, C.7, C8	Values for hardenabili-ty according to Tables C.9, C.10 and C.11	Chemical compo-sition as specified in Tables C.2 and C.3	Mechanical proper- ties as specified in Tables C.4, C.5 , C.6, C.7 and C.8	Minimum core hard-ness and maximum diameter according to Table C.12	Supplementary or special requirements as specified in Annex D[b]
ii)	Cold drawn	+AR +C	—	x	x									
iii)	Cold drawn + Spheroidized	+AR +C + AC	—	X	x									
iv)	Cold drawn + spheroidized + skin passed	+AR +C +AC +LC	—	x	X									
v)	Spheroidized or spheroidized + peeled	+AC or +AC +PE	X	X	X									
vi)	Spheroidized + cold drawn	+AC + C	—	x	x									
vii)	Spheroidized + cold drawn + spheroidized	+AC + C + AC	—	x	x									
viii)	Spheroidized + cold drawn +spheroidized +skin passed	+AC + C + AC + LC	—	x	x									
ix)	Others	Other delivery conditions may be agreed at the time of ordering												

[a] X = applicable, — = not applicable.
[b] If agreed at the time of the enquiry and order.

Table C.2 Chemical Composition (Applicable to Ladle Analysis) of Steel Without Boron for Quenching and Tempering

(*Clauses* 4.3, 7.1 *and* 15.1)

Sl No.	Steel designation[b]	Percent mass fraction[a]								
		C	Si	Mn	P	S	Cr	Ni	Mo	Cu
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	20C8	0.15 to 0.25	-e	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	0.15[d]
ii)	20C15	0.16 to 0.24	0.10 to 0.35	1.30 to 1.70	0.035	0.035	0.15	0.15	0.05	0.15[d]
iii)	25C8	0.20 to 0.30	-e	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	0.15[d]
iv)	27C15	0.22 to 0.32	0.10 to 0.35	1.30 to 1.70	0.035	0.035	0.15	0.15	0.05	0.15[d]
v)	30C7	0.27 to 0.33	0.30[c]	0,50 to 0,80	0.025	0.025	—	—	—	0.25
vi)	30C8	0.25 to 0.35	0.10 to 0.35	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	0.15[d]
vii)	30C7S3	0.27 to 0.33	0.30[c]	0.50 to 0.80	0.025	0.020 to 0.035	—	—	—	0.25
viii)	35C7	0.32 to 0.39	0.30[c]	0,50 to 0,80	0.025	0.025	—	—	—	0.25
ix)	35C8	0.30 to 0.40	0.10 to 0.35	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	0.15[d]
x)	37C15	0.32 to 0.42	0.10 to 0.35	1.30 to 1.70	0.035	0.035	0.15	0.15	0.05	0.15[d]
xi)	35C7S3	0.32 to 0.39	0.30[c]	0.50 to 0.80	0.025	0.020 to 0.035	—	—	—	0.25
xii)	40C8	0.35 to 0.45	0.10 to 0.35	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	0.15[d]
xiii)	40C15	0.36 to 0.44	-e	1.35 to 1.65	0.030	0.050	0.20	0.25	0.06	0.35
xiv)	45C7	0.42 to 0.50	0.30[c]	0,50 to 0,80	0.025	0.025	—	—	—	0.25
xv)	45C8	0.40 to 0.50	0.10 to 0.35	0.60 to 0.90	0.035	0.035	0.15	0.15	0.05	0.15[d]
xvi)	45C7S3	0.42 to 0.50	0.30[c]	0.50 to 0.80	0.025	0.020 to 0.035	—	—	—	0.25
xvii)	37Mo2	0.35 to 0.40	0.30[c]	0.60 to 0.90	0.025	0.025	—	—	0.20 to 0.30	0.25
xviii)	38Cr2	0.35 to 0.42	0.30[c]	0.50 to 0.80	0.025	0.025	0.40 to 0.60	—	—	0.25
xix)	46Cr2	0.42 to 0.50	0.30[c]	0.50 to 0.80	0.025	0.025	0.40 to 0.60	—	—	0.25
xx)	34Cr4	0.30 to 0.37	0.30[c]	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	—	0.25
xxi)	37Cr4	0.34 to 0.41	0.30[c]	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	—	0.25
xxii)	40Cr4	0.35 to 0.45	0.10 to 0.35	0.60 to 0.90	0.035	0.035	0.90 to 1.20	0.15	0.05	0.15[d]
xxiii)	41Cr4S3	0.38 to 0.45	0.30[c]	0.60 to 0.90	0.025	0.020 to 0.040	0.90 to 1.20	—	—	0.25
xxiv)	25Cr4Mo2	0.22 to 0.29	0.30[c]	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	0.15 to 0.30	0.25
xxv)	25Cr4Mo2S3	0.22 to 0.29	0.30[c]	0.60 to 0.90	0.025	0.020 to 0.040	0.90 to 1.20	—	0.15 to 0.30	0.25
xxvi)	34Cr4Mo2	0.30 to 0.37	0.30[c]	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	0.15 to 0.30	0.25
xxvii)	37Cr4Mo2	0.35 to 0.40	0.30[c]	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	0.15 to 0.30	0.25

Table C.2 (*Concluded*)

xxviii)	40Cr4Mo3	0.35 to 0.45	0.10 to 0.35	0.50-0.80	0.035	0.035	0.90 to 1.20	—	0.20 to 0.35	0.15[d]
xxix)	42Cr4Mo2	0.38 to 0.45	0.30[c]	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	0.15 to 0.30	0.25
xxx)	42Cr4Mo2S3	0.38 to 0.45	0.30[c]	0.60 to 0.90	0.025	0.020 to 0.040	0.90 to 1.20	—	0.15 to 0.30	0.25
xxxi)	41Cr2Ni2Mo2	0.37 to 0.44	0.30[c]	0.70 to 1.00	0.025	0.025	0.40 to 0.60	0.40 to 0.70	0.15 to 0.30	0.25
xxxii)	41Cr2Ni2Mo2S3	0.37 to 0.44	0.30[c]	0.70 to 1.00	0.025	0.020 to 0.040	0.40 to 0.60	0.40 to 0.70	0.15 to 0.30	0.25
xxxiii)	34Cr6Ni6Mo2	0.30 to 0.38	0.30[c]	0.50 to 0.80	0.025	0.025	1.30 to 1.70	1.30 to 1.70	0.15 to 0.30	0.25
xxxiv)	41Ni7Cr3Mo2	0.38 to 0.44	0.30[c]	0.60 to 0.90	0.025	0.025	0.70 to 0.90	1.65 to 2.00	0.15 to 0.30	0.25
xxxv)	35Mn6Mo3	0.30 to 0.40	0.10 to 0.35	1.30 to 1.80	0.035	0.035	0.15	0.15	0.20 to 0.35	0.15[d]
xxxvi)	35Mn6Mo4	0.30 to 0.40	0.10 to 0.35	1.30 to 1.80	0.035	0.035	0.15	0.15	0.35 to 0.55	0.15[d]
xxxvii)	25Cr13Mo6	0.20 to 0.30	0.10 to 0.35	0.40 to 0.70	0.035	0.035	2.90 to 3.40	0.15	0.45 to 0.65	0.15[d]
xxxviii)	40Ni4	0.35 to 0.45	0.10 to 0.35	0.50 to 0.80	0.035	0.035	0.30	3.20 to 3.60	0.05	0.15[d]
xxxix)	35Ni5Cr2	0.30 to 0.40	0.10 to 0.35	0.60 to 0.90	0.035	0.035	0.45 to 0.75	1.00 to 1.50	0.05	0.15[d]
xl)	30Ni13Cr5	0.26 to 0.34	0.10 to 0.35	0.40 to 0.70	0.035	0.035	1.10 to 1.45	3.90 to 4.30	0.05	0.15[d]
xli)	40Cr4Mo2	0.38 to 0.43	0.15 to 0.35	0.75 to 1.00	0.030	0.040	0.80 to 1.10	0.25	0.15 to 0.25	0.35
xlii)	35Cr4Mo2	0.33 to 0.38	0.15 to 0.35	0.70 to 0.90	0.030	0.040	0.80 to 1.10	0.25	0.15 to 0.25	0.35
xliii)	41Cr3	0.38 to 0.43	0.15 to 0.35	0.70 to 0.90	0.030	0.040	0.70 to 0.90	0.25	0.06	0.35

Elements not quoted in this table should not be intentionally added to the steel without the agreement of the purchaser, except those intended for finishing the heat.

[a] Maximum values unless otherwise indicated.

[b] In the case of steels with hardenability requirements (*see* Tables C.9 and C.11), minor deviations from the specified limits are permitted (with the exception of sulphur and phosphorus), provided that they do not exceed 0.01% for carbon and the values indicated in Table 1 for the other elements. However, the limits for product analysis for such cases to be considered against the values given in Table C.2.

[c] Lower silicon contents may be agreed at the time of ordering, in which case due consideration should be given to the effects that could result for what concerns the specified properties such as, for example, hardenability.

[d] For these grades Sn = 0.020% *Max* and V = 0.05% *Max* and total of Cr, Ni, Cu, Sn, Mo and V shall not exceed 0.40%, wherever not applicable as an alloying element.

[e] As agreed between manufacturer and supplier.

Table C.3 Chemical Composition (Applicable to Ladle Analysis) of Boron Based Steel Grades for Quenching and Tempering
(*Clauses* 4.3, 7.1 *and* 15.1)

Sl No. (1)	Steel designation[b] (2)	Percent mass fraction[a]								
		C (3)	Si (4)	Mn (5)	P (6)	S (7)	Cr[d] (8)	Mo (9)	B (10)	Cu (11)
i)	17C8BT	0.15 to 0.20	0.30[c]	0.60 to 0.90	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
ii)	23C8BT	0.20 to 0.25	0.30[c]	0.60 to 0.90	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
iii)	28C8BT	0.25 to 0.30	0.30[c]	0.60 to 0.90	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
iv)	33C8BT	0.30 to 0.35	0.30[c]	0.60 to 0.90	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
v)	38C8BT	0.35 to 0.40	0.30[c]	0.60 to 0.90	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
vi)	23Cr1BT	0.21 to 0.25	0.15	0.80 to 1.00	0.015	0.015	0.25 to 0.35	—	0.000 8 to 0.005	0.25
vii)	17C10BT	0.15 to 0.20	0.30[c]	0.90 to 1.20	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
viii)	20C10BT	0.18 to 0.23	0.30[c]	0.90 to 1.20	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
ix)	21C10BT	0.18 to 0.23	0.15 to 0.30	0.80 to 1.10	0.035	0.035	0.15	0.05	0.000 5 to 0.003	0.15[f]
x)	23C10BT	0.20 to 0.25	0.30[c]	0.90 to 1.20	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xi)	26C10BT	0.23 to 0.29	0.15 to 0.30	0.90 to 1.20	0.035	0.035	0.15	0.05	0.000 5 to 0.003	0.15f
xii)	27C10BT	0.25 to 0.30	0.30[c]	0.90 to 1.20	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xiii)	30C10BT	0.27 to 0.32	0.30[c]	0.80 to 1.10	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xiv)	36C10BT	0.33 to 0.38	0.30[c]	0.80 to 1.10	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xv)	20C13BT	0.17 to 0.23	0.30[c]	1.10 to 1.40	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xvi)	23C13BT	0.20 to 0.26	0.30[c]	1.10 to 1.40	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xvii)	26C13BT	0.23 to 0.29	0.30[c]	1.20 to 1.50	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xviii)	34C14BT	0.32 to 0.37	0.15 to 0.30	1.20 to 1.50	0.035	0.035	0.15	0.05	0.000 5 to 0.003	0.15[f]
xix)	35C14BT	0.31 to 0.37	0.30[c]	1.20 to 1.50	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xx)	37C13BT	0.35 to 0.40	0.30[c]	1.15 to 1.45	0.025	0.025	0.30	—	0.000 8 to 0.005	0.25
xxi)	30Mo1BT	0.28 to 0.32	0.30[c]	0.80 to 1.00	0.025	0.025	0.30[e]	0.08 to 0.12	0.000 8 to 0.005	0.25
xxii)	32Cr4BT	0.30 to 0.34	0.30[c]	0.60 to 0.90	0.025	0.025	0.90 to 1.20	—	0.000 8 to 0.005	0.25
xxiii)	36Cr4BT	0.34 to 0.38	0.30[c]	0.70 to 1.00	0.025	0.025	0.90 to 1.20	—	0.000 8 to 0.005	0.25

Table C.3 (*Continued*)

xxiv)	31Cr2Mo1BT	0.28 to 0.33	0.30[c]	0.90 to 1.20	0.025	0.025	0.40 to 0.55	0.10 to 0.15	0.000 8 to 0.005	0.25
xxv)	38Cr4BT	0.35 to 0.40	0.15 to 0.30	0.30 to 0.50	0.035	0.035	0.95 to 1.15	0.05	0.0005 to 0.003	0.15[f]

Elements not quoted in this table should not be intentionally added to the steel without the agreement of the purchaser, except those intended for finishing the heat.
To improve the performance of cold heading, it is possible to add Al:0.020% to 0.050%.
[a] Maximum values unless otherwise indicated.
[b] In the case of steels with hardenability requirements (*see* Table C.10), minor deviations from the specified limits are permitted (with the exception of sulphur and phosphorus), provided that they do not exceed 0.01% for carbon and the values indicated in Table 1 for the other elements. However, the limits for product analysis for such cases to be considered against the values given in Table C.3.
[c] Lower silicon contents may be agreed at the time of ordering, in which case due consideration should be given to the effects that could result for what concerns the specified properties such as, for example, hardenability.
[d] Where a maximum chromium content of 0.30% is specified, a minimum level may also be agreed at the time of enquiry and order.
[e] In order to obtain a core hardening for the steel grade 30Mo1BT, the lower limit of Cr shall be 0.15 % and may be agreed at the time of enquiry and order. For certain applications, the higher limit for Cr may also be lowered by agreement at time of enquiry and order.
[f] For these grades Sn = 0.020% max and V = 0.05% max and total of Cr, Ni, Cu, Sn, Mo and V shall not exceed 0.40%, wherever not applicable as an alloying element.

Table C.3 (*Concluded*)

Sl No.	**Steel designation**	**Percent mass fraction[a]**									
		C	**Si**	**Mn**	**P**	**S**	**Cr**	**Ni**	**Mo**	**B**	**Cu**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	21C8BT	0.18 to 0.23	-b	0.60 to 0.90	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
ii)	22C9BT	0.18 to 0.23	-b	0.70 to 1.00	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
iii)	23C5BT	0.20 to 0.25	-b	0.30 to 0.60	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
iv)	26C9BT	0.23 to 0.29	-b	0.80 to 1.10	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
v)	21C13BT	0.18 to 0.23	-b	1.10 to 1.40	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
vi)	25C5BT	0.22 to 0.28	-b	0.30 to 0.60	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
vii)	33C9BT	0.30 to 0.36	-b	0.70 to 1.00	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
viii)	35C7BT	0.32 to 0.38	-b	0.50 to 0.80	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
ix)	35C8BT	0.32 to 0.38	-b	0.60 to 0.90	0.040	0.050	0.20	0.25	0.060	0.0005 to 0.003	0.35
x)	40C15BT	0.36 to 0.44	-b	1.35 to 1.65	0.040	0.050	0.50	0.25	0.060	0.0005 to 0.003	0.35

Elements not quoted in this table should not be intentionally added to the steel without the agreement of the purchaser, except those intended for finishing the heat.

[a] Maximum values unless otherwise indicated.

[b] As agreed to between manufacturer and purchaser

Table C.4 Mechanical Properties for Non-Alloy Steel Grades without Boron

(*Clauses* 8.1 *and* 8.2.1)

Sl No.	Steel designation	Diameter[b]		Delivery condition							
				+AC or +AC+PE		+AR+C+AC		+AR+C+AC+LC		+AC+C	
		above	up to	**Rm** *Max*	**Z** *Min*	**Rm** *Max*	**Z** *Min*	**Rm** *Max*	**Z** *Min*	**Rm** *Max*	**Z** *Min*
		mm	mm	MPa	%	MPa	%	MPa	%	MPa	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	30C7 30C7S3	2[a]	5	—	—	—	—	620	55	—	—
		5	10	—	—	—	—	620	55	620	55
		10	40	590	—	—	—	620	55	620	55
ii)	35C7 35C7S3	2[a]	5	—	—	550	62	590	60	—	—
		5	10	560	60	540	62	580	60	670	—
		10	40	560	60	540	62	580	60	660	—
iii)	45C7 45C7S3	2[a]	5	—	—	590	62	630	60	—	—
		5	10	600	60	580	62	620	60	720	—
		10	40	600	60	580	62	620	60	710	—

[a] Including 2 mm.
[b] For non-circular cross-section, properties may be as agreed to between manufacturer and purchaser.

Table C.5 Mechanical Properties for Alloy Steel Grades without Boron
(*Clauses* 8.1 *and* 8.2.1)

Sl No.	Steel designation	Diameter[b]		Delivery condition					
				+AC or +AC+PE		+AC+C+AC		+AC+C+AC+LC	
		above	up to	**Rm** *Max*	**Z** *Min*	**Rm** *Max*	**Z** *Min*	**Rm** *Max*	**Z** *Min*
		mm	mm	MPa	%	MPa	%	MPa	%
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	37Mo2	2[a]	5	—	—	560	61	600	59
		5	40	570	59	550	61	590	59
ii)	38Cr2	2[a]	5	—	—	590	62	630	60
		5	40	600	60	580	62	620	60
iii)	46Cr2	2[a]	5	—	—	610	60	650	58
		5	40	620	58	600	60	640	58
iv)	34Cr4	2[a]	5	—	—	570	64	610	62
		5	40	580	62	560	64	600	62
v)	37Cr4	2[a]	5	—	—	580	62	620	60
		5	40	590	60	570	62	610	60
vi)	40Cr4 41Cr4S3	2[a]	5	—	—	610	60	650	58
		5	40	620	58	600	60	640	58
vii)	25Cr4Mo2 25Cr4Mo2S3	2[a]	5	—	—	570	62	610	60
		5	40	580	60	560	62	600	60
viii)	34Cr4Mo2	2[a]	5	—	—	590	62	630	60
		5	40	600	60	580	62	620	60
ix)	37Cr4Mo2	2[a]	5	—	—	610	62	650	60
		5	40	620	60	600	62	640	60

Table C.5 (*Concluded*)

x)	42Cr4Mo2	2[a]	5	—	—	620	60	660	58
	42Cr4Mo2S3	5	40	630	58	610	60	650	58
xi)	41Cr2Ni2Mo2	2[a]	5	—	—	640	60	680	55
	41Cr2Ni2Mo2S3	5	40	—	—	640	60	680	55
xii)	34Cr6Ni6Mo2	2[a]	5	—	—	710	60	750	58
		5	40	720	58	700	60	740	58
xiii)	41Ni7Cr3Mo2	2[a]	5	—	—	710	60	750	58
		5	40	720	58	700	60	740	58

[a] Including 2 mm.
[b] For non-circular cross-section, properties may be as agreed to between manufacturer and purchaser.

Table C.6 Maximum Hardness for Products Delivered in Annealed Condition (+AC)

(*Clauses* 8.1 *and* 8.2.1)

Sl No.	**Steel designation**	**Brinell hardness**, *Max* HBW
(1)	(2)	(3)
i)	20C8	150
ii)	25C8	150
iii)	30C8	160
iv)	35C8	160
v)	40C8	170
vi)	45C8	170
vii)	20C15	170
viii)	27C15	190
ix)	37C15	190
x)	35Mn6Mo3	190
xi)	35Mn6Mo4	190
xii)	40Cr4Mo3	200
xiii)	25Cr13Mo6	190
xiv)	40Ni4	190
xv)	35Ni5Cr2	190
xvi)	30Ni3Cr5	200

Table C.7 Mechanical Properties for Boron Alloyed Steel Grades

(*Clauses* 8.1 *and* 8.2.1)

Sl No.	Steel designation	Diameter[b]		Delivery condition Mechanical properties											
				+AR or +PE		+AC or +AC+PE		+AR+C		+AR+C+AC		+AR+C+AC+LC		+AC+C	
		above mm	up to mm	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* %	**Rm** *Max* MPa	**Z** *Min* **%**	**Rm** *Max* MPa	**Z** *Min* **%**	**Rm** *Max* MPa	**Z** *Max* %
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	17C8BT	2[a]	5	—	—	—	—	—	—	450	70	490	68	—	—
		5	10	540	60	460	68	630	55	440	70	480	68	550	63
		10	25	540	60	460	68	620	55	440	70	480	68	540	63
ii)	23C8BT	2[a]	5	—	—	—	—	—	—	480	68	520	66	—	—
		5	10	600	60	490	66	690	55	470	68	510	66	580	61
		10	25	600	60	490	66	680	55	470	68	510	66	570	61
iii)	28C8BT	2[a]	5	—	—	—	—	—	—	510	66	550	64	—	—
		5	10	630	60	520	64	720	55	500	66	540	64	610	59
		10	25	630	60	520	64	710	55	500	66	540	64	600	59
iv)	33C8BT	2[a]	5	—	—	—	—	—	—	540	64	580	62	—	—
		5	10	—	—	550	62	—	—	530	64	570	62	640	57
		10	40	—	—	550	62	—	—	530	64	570	62	630	57
v)	38C8BT	2[a]	5	—	—	—	—	—	—	560	64	600	62	—	—
		5	10	—	—	570	62	—	—	550	64	590	62	660	57
		10	40	—	—	570	62	—	—	550	64	590	62	650	57
vi)	23Cr1BT	2[a]	5	—	—	—	—	—	—	510	66	550	64	—	—
		5	10	600	60	520	64	700	55	500	66	540	64	620	59
		10	25	600	60	520	64	690	55	500	66	540	64	610	59
vii)	17C10BT	2[a]	5	—	—	—	—	—	—	470	69	510	67	—	—
		5	10	570	60	480	67	660	55	460	69	500	67	570	62
		10	25	570	60	480	67	650	55	460	69	500	67	560	62

Table C.7 (*Continued*)

Sl No.	Steel designation	Diameter[b]		+AR or +PE		+AC or +AC+PE		Delivery condition +AR+C +AR+C+AC Mechanical properties				+AR+C+AC+LC		+AC+C	
		above	up to	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %
		mm	mm												
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
viii)	20C10BT	2[a]	5	—	—	—	—	—	—	490	68	530	66	—	—
		5	10	580	60	500	66	680	55	480	68	520	66	600	61
		10	25	580	60	500	66	670	55	480	68	520	66	590	61
ix)	23C10BT	2[a]	5	—	—	—	—	—	—	510	66	550	64	—	—
		5	10	600	60	520	64	700	55	500	66	540	64	620	59
		10	25	600	60	520	64	690	55	500	66	540	64	610	59
x)	27C10BT	2[a]	5	—	—	—	—	—	—	530	65	570	63	—	—
		5	40	—	—	540	63	—	—	520	65	560	63	640	58
xi)	30C10BT	2[a]	5	—	—	—	—	—	—	560	65	600	63	—	—
		5	40	—	—	570	63	—	—	550	65	590	63	670	58
xii)	36C10BT	2[a]	5	—	—	—	—	—	—	590	64	630	62	—	—
		5	40	—	—	600	62	—	—	580	64	620	62	700	57
xiii)	20C13BT	2[a]	5	—	—	—	—	—	—	—	—	630	55	—	—
		5	40	—	—	—	—	—	—	—	—	630	55	630	55
xiv)	23C13BT	2[a]	5	—	—	—	—	—	—	—	—	640	55	—	—
		5	40	—	—	—	—	—	—	—	—	640	55	640	55
xv)	26C13BT	2[a]	5	—	—	—	—	—	—	—	—	650	55	—	—
		5	40	—	—	—	—	—	—	—	—	650	55	650	55
xvi)	34C13BT	2[a]	5	—	—	—	—	—	—	—	—	680	55	—	—
		5	40	—	—	—	—	—	—	—	—	680	55	680	55
xvii)	37C13BT	2[a]	5	—	—	—	—	—	—	610	64	650	62	—	—
		5	40	—	—	620	62	—	—	600	64	640	62	720	57

Table C.7 (*Concluded*)

Sl No.	Steel Designation	Diameter[b]		+AR or +PE		+AC or +AC+PE		Delivery condition +AR+C +AR+C+AC Mechanical properties				+AR+C+AC+LC		+AC+C	
		above	up to	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %	R_m *Max* MPa	Z *Min* %
(1)	(2)	mm (3)	mm (4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
xviii)	30Mo1BT	2[a]	5	—	—	—	—	—	—	530	64	570	62	—	—
		5	40	—	—	530	62	—	—	510	64	550	62	630	57
xix)	32Cr4BT	2[a]	5	—	—	—	—	—	—	550	64	590	62	—	—
		5	40	—	—	550	62	—	—	530	64	570	62	670	57
xx)	36Cr4BT	2[a]	5	—	—	—	—	—	—	570	63	610	61	—	—
		5	40	—	—	570	61	—	—	550	63	590	61	690	56
xxi)	31Cr2Mo1BT	2[a]	5	—	—	—	—	—	—	570	63	610	61	—	—
		5	40	—	—	570	61	—	—	550	63	590	61	690	56

It should be recognized in the +AR condition that the tensile strength values are not compatible with the whole range of composition given in Table C.3 for a steel grade. Care should be taken that, depending on diameter and composition supplied, the tensile strength values are compatible with the hardenability requirements.

[a] Including 2 mm.

[b] For non-circular cross-section, properties may be as agreed to between manufacturer and purchaser.

Table C.8 Maximum Hardness for Boron Alloyed Products Delivered in Annealed Condition (+AC)
(*Clauses* 8.1 *and* 8.2.1)

Sl No.	**Steel Designation**	**Brinell Hardness**, *Max* HBW
(1)	(2)	(3)
i)	21C10BT	160
ii)	26C10BT	160
iii)	34C14BT	190
iv)	38Cr4BT	200

Table C.9 Hardness Limits for Steel Grades Without Boron with Specified (Normal) Hardenability (H Grades)
(*Clause* 7.1,8.2.1 *and* 8.2.3)

Sl No.	Steel Designation	Symbol	Austenitizing temperature °C ± 5°C	Limits of range	Hardness HRC at a distance from quenched end of test piece (in mm) of															
					1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**13**	**15**	**20**	**25**	**30**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
i)	35C7 35C7S3	H	870	*Max*	58	57	55	53	49	41	34	31	28	27	26	25	24	23	20	—
		H		*Min*	48	40	33	24	22	20	—	—	—	—	—	—	—	—	—	—
ii)	45C7 45C7S3	H	850	*Max*	61	60	59	57	53	47	39	34	31	30	29	28	27	26	25	24
		H		*Min*	51	46	35	27	25	24	23	22	21	20	—	—	—	—	—	—
					at a distance from quenched end of test piece (in mm) of															
					1.5	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	—
iii)	37Mo2	H	850	*Max*	59	57	53	47	41	36	32	29	27	25	—	—	—	—	—	—
				Min	51	48	41	33	27	26	22	20	—	—	—	—	—	—	—	—
iv)	38Cr2	H	850	*Max*	59	57	54	49	43	39	37	35	32	30	27	25	24	23	22	—
				Min	51	46	37	29	25	22	20	—	—	—	—	—	—	—	—	—
v)	46Cr2	H	850	*Max*	63	61	57	52	46	42	40	38	35	33	31	29	28	27	26	—
				Min	54	49	40	32	28	25	23	22	20	—	—	—	—	—	—	—
vi)	34Cr4	H	850	*Max*	57	57	56	54	52	49	46	44	39	37	35	34	33	32	31	—
				Min	49	48	45	41	35	32	29	27	23	21	20	—	—	—	—	—
vii)	37Cr4	H	850	*Max*	59	59	58	57	55	52	50	48	42	39	37	36	35	34	33	—
				Min	51	50	48	44	39	36	33	31	26	24	22	20	—	—	—	—
viii)	40Cr4 41Cr4S3	H	850	*Max*	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35	—
				Min	53	52	50	47	41	37	34	32	29	26	23	21	—	—	—	—
ix)	25Cr4Mo2 25Cr4Mo2S3	H	850	*Max*	52	52	51	50	48	46	43	41	37	35	33	32	31	31	31	—
				Min	44	43	40	37	34	32	29	27	23	21	20	—	—	—	—	—

Table C.9 (*Continued*)

x)	34Cr4Mo2	H	850	*Max*	57	57	57	56	55	54	53	52	48	45	43	41	40	40	39	—
				Min	49	49	48	45	42	39	36	34	30	28	27	26	25	24	24	—
xi)	37Cr4Mo2	H	850	*Max*	60	60	60	59	58	56	55	54	51	48	46	45	—	—	—	—
				Min	52	50	49	47	45	43	40	37	34	32	31	30	—	—	—	—
xii)	42Cr4Mo2 42Cr4Mo2S3	H	850	*Max*	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45	—
				Min	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29	—
xiii)	41Cr2Ni2Mo2 41Cr2Ni2Mo2S3	H	850	*Max*	60	60	60	59	58	57	55	54	48	42	40	38	37	37	36	—
				Min	53	53	52	50	47	42	38	35	30	28	26	25	24	24	23	—
xiv)	34Cr6Ni6Mo2	H	850	*Max*	58	58	58	58	57	57	57	57	57	57	57	57	57	57	57	—
				Min	50	50	50	50	49	48	48	48	48	47	47	47	46	45	44	—
xv)	41Ni7Cr3Mo2	H	850	*Max*	60	60	60	60	60	60	60	59	59	58	58	57	57	—	—	—
				Min	54	54	54	54	54	54	54	54	53	52	52	51	50	—	—	—

Table C.9 (*Concluded*)

Sl No.	**Steel Designation**	**Symbol**	**Austenitizing temperature** °C ± 5°C	**Limits of range**	**Hardness HRC at a distance from quenched end of test piece (in 25.4/16 mm) of**																					
					1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**20**	**22**	**24**	**26**	**28**	**30**	**32**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)
i)	35Cr4Mo2	H	850	*Max*	58	58	57	56	56	55	54	53	52	51	50	49	48	47	46	45	44	42	41	40	39	38	38	37
				Min	51	50	49	48	47	45	42	40	38	36	34	33	32	31	30	30	29	28	27	27	27	26	26	26
ii)	40Cr4Mo2	H	850	*Max*	60	60	60	59	59	58	58	57	57	56	56	55	55	54	54	53	52	51	49	48	47	46	45	44
				Min	53	53	52	51	51	50	48	47	44	42	40	39	38	37	36	35	34	33	33	32	32	31	31	30
iii)	41Cr3	H	850	*Max*	60	59	58	57	56	54	52	50	48	46	45	43	42	40	39	38	37	36	35	34	34	33	33	32
				Min	53	52	50	48	43	38	35	33	31	30	29	28	27	27	26	25	24	23	21	20	-	-	-	-

Table C.10 Hardness Limits for Boron Alloyed Steel Grades with Standard Hardenability (H Grades)
(*Clauses* 7.1, 8.2.1 *and* 8.2.3)

Sl No.	Steel Designation	Symbol	Austenitizing temperature °C ± 5°C	Limits of range	Hardness HRC at a distance from quenched end of test piece (in mm) of														
					1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
i)	17C8BT	H	900	*Max*	46	45	45	41	35	—	—	—	—	—	—	—	—	—	—
				Min	39	34	30	20	—	—	—	—	—	—	—	—	—	—	—
ii)	23C8BT	H	890	*Max*	49	48	47	45	39	—	—	—	—	—	—	—	—	—	—
				Min	41	39	37	21	—	—	—	—	—	—	—	—	—	—	—
iii)	28C8BT	H	880	*Max*	53	51	51	49	45	39	29	24	20	—	—	—	—	—	—
				Min	46	42	39	23	—	—	—	—	—	—	—	—	—	—	—
iv)	33C8BT	H	870	*Max*	55	55	54	52	49	43	—	—	—	—	—	—	—	—	—
				Min	49	45	43	27	20	—	—	—	—	—	—	—	—	—	—
v)	38C8BT	H	860	*Max*	58	57	56	55	51	49	44	—	—	—	—	—	—	—	—
				Min	51	49	47	36	25	20	—	—	—	—	—	—	—	—	—
vi)	23Cr1BT	H	880	*Max*	49	48	47	47	45	41	—	—	—	—	—	—	—	—	—
				Min	43	41	40	32	23	—	—	—	—	—	—	—	—	—	—
vii)	17C10BT	H	890	*Max*	47	46	46	44	41	36	—	—	—	—	—	—	—	—	—
				Min	40	38	37	30	20	—	—	—	—	—	—	—	—	—	—
viii)	20C10BT	H	880	*Max*	48	48	47	46	44	39	—	—	—	—	—	—	—	—	—
				Min	41	40	37	30	20	—	—	—	—	—	—	—	—	—	—
ix)	23C10BT	H	880	*Max*	49	48	47	47	45	41	—	—	—	—	—	—	—	—	—
				Min	43	41	40	32	23	—	—	—	—	—	—	—	—	—	—
x)	27C10BT	H	870	*Max*	53	52	51	50	48	45	41	—	—	—	—	—	—	—	—
				Min	46	44	43	36	27	21	—	—	—	—	—	—	—	—	—

Table C.10 (*Concluded*)

xi)	30C10BT	H	860	*Max*	54	53	53	53	51	46	42	—	—	—	—	—	—	—	—
				Min	48	46	44	36	25	20	—	—	—	—	—	—	—	—	—
xii)	36C10BT	H	850	*Max*	58	57	57	56	54	52	48	43	—	—	—	—	—	—	—
				Min	51	49	48	43	31	25	20	—	—	—	—	—	—	—	—
xiii)	20C13BT	H	925	*Max*	48	48	48	47	46	44	40	36	29	25	21	—	—	—	—
				Min	40	39	37	30	22	—	—	—	—	—	—	—	—	—	—
xiv)	23C13BT	H	870	*Max*	50	50	49	48	48	46	44	41	30	22	—	—	—	—	—
				Min	42	41	39	35	27	20	—	—	—	—	—	—	—	—	—
xv)	26C13BT	H	870	*Max*	52	52	52	51	50	49	48	45	36	27	23	20	—	—	—
				Min	44	43	42	40	34	27	23	20	—	—	—	—	—	—	—
xvi)	34C13BT	H	845	*Max*	57	56	56	55	55	54	53	51	43	33	28	25	22	20	—
				Min	49	48	47	45	43	37	31	26	20	—	—	—	—	—	—
xvii)	37C13BT	H	850	*Max*	60	60	59	58	57	57	55	53	48	—	—	—	—	—	—
				Min	52	51	50	48	43	37	32	29	—	—	—	—	—	—	—
xviii)	30Mo1BT	H	870	*Max*	53	52	52	51	49	48	46	43	34	—	—	—	—	—	—
				Min	47	46	45	39	30	24	21	—	—	—	—	—	—	—	—
xix)	32Cr4BT	H	860	*Max*	56	56	55	55	55	54	53	53	51	49	45	42	40	38	—
				Min	49	48	47	46	46	45	—	—	—	—	—	—	—	—	—
xx)	36Cr4BT	H	850	*Max*	58	58	57	56	56	55	55	55	53	51	48	46	—	—	—
				Min	50	49	48	48	47	46	46	45	34	30	27	—	—	—	—
xxi)	31Cr2Mo1BT	H	860	*Max*	54	54	54	53	53	52	51	51	48	43	41	—	—	—	—
				Min	48	48	47	47	45	45	41	39	31	27	25	—	—	—	—

Table C.11 Hardness Limits for Steel Grades without Boron with Restricted Hardenability Scatter Bands (HH and HL Grades)a
(*Clauses* 7.1, 8.2.1, *and* 8.2.3)

Sl No.	Steel designation	Symbol	Austenitizing temperature °C ± 5°C	Limits of range	Hardness HRC at a distance from quenched end of test piece (in mm) of														
					1.5	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
i)	37Mo2	HH	850	*Max*	59	57	53	47	41	36	32	29	27	25	—	—	—	—	—
				Min	54	51	45	38	32	29	25	23	—	—	—	—	—	—	—
		HL		*Max*	56	54	49	42	36	33	29	26	—	—	—	—	—	—	—
				Min	51	48	41	33	27	26	22	20	—	—	—	—	—	—	—
ii)	38Cr2	HH	850	*Max*	59	57	54	49	43	39	37	35	32	30	27	25	24	23	22
				Min	54	50	43	36	31	28	26	24	21	—	—	—	—	—	—
		HL		*Max*	56	53	48	42	37	33	31	29	26	24	21	—	—	—	—
				Min	51	46	37	29	25	22	20	—	—	—	—	—	—	—	—
iii)	46Cr2	HH	850	*Max*	61	59	56	51	46	41	39	37	33	31	29	27	26	25	24
				Min	55	51	45	38	33	30	28	26	22	20	—	—	—	—	—
		HL		*Max*	56	55	50	44	39	35	33	31	27	25	23	21	20	—	—
				Min	52	47	39	31	27	24	22	—	—	—	—	—	—	—	—
iv)	34Cr4	HH	850	*Max*	57	57	56	54	52	49	46	44	39	37	35	34	33	32	31
				Min	52	51	49	45	41	38	35	33	28	26	25	24	23	22	21
		HL		*Max*	54	54	52	50	46	43	40	38	34	32	30	29	28	27	26
				Min	49	48	45	41	35	32	29	27	23	21	20	—	—	—	—
v)	37Cr4	HH	850	*Max*	59	59	58	57	55	52	50	48	42	39	37	36	35	34	33
				Min	54	53	51	48	44	41	39	37	31	29	27	25	24	23	22
		HL		*Max*	56	56	55	53	50	47	44	42	37	34	32	31	30	29	28
				Min	51	50	48	44	39	36	33	31	26	24	22	20	—	—	—
vi)	40Cr4 41Cr4S3	HH	850	*Max*	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35
				Min	56	55	53	51	47	43	41	39	35	31	29	27	26	25	24
		HL		*Max*	58	58	57	55	52	50	47	45	40	37	34	32	31	30	29
				Min	53	52	50	47	41	37	34	32	29	26	23	21	—	—	—

a This table is not applicable to steels ordered with a restricted range of carbon content, *see* footnote c) in Table C.2.

Table C.11 (*Concluded*)

Sl No.	Steel grade	Symbol	Austenitizing temperature °C ± 5°C	Limits of range	Hardness HRC at a distance from quenched end of test piece (in mm) of														
					1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
vii)	25Cr4Mo2 25Cr4Mo2S3	HH	850	*Max*	52	52	51	50	48	46	43	41	37	35	33	32	31	31	31
				Min	47	46	44	41	39	37	34	32	28	26	24	23	22	22	22
		HL		*Max*	49	49	47	46	43	41	38	36	32	30	29	28	27	27	27
				Min	44	43	40	37	34	32	29	27	23	21	20	—	—	—	—
viii)	34Cr4Mo2	HH	850	*Max*	57	57	57	56	55	54	53	52	48	45	43	41	40	40	39
				Min	52	52	51	49	46	44	42	40	36	34	32	31	30	29	29
		HL		*Max*	54	54	54	52	51	49	47	46	42	39	38	36	35	35	34
				Min	49	49	48	45	42	39	36	34	30	28	27	26	25	24	24
ix)	37Cr4Mo2	HH	850	*Max*	60	60	60	59	58	56	55	54	51	48	46	45	—	—	—
				Min	55	53	53	51	49	47	45	45	40	39	36	36	—	—	—
		HL		*Max*	57	57	56	55	54	52	50	46	44	41	41	39	—	—	—
				Min	52	50	50	47	45	43	40	37	34	32	31	30	—	—	—
x)	42Cr4Mo2 42Cr4Mo2S3	HH	850	*Max*	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45
				Min	56	56	55	54	52	48	46	44	41	39	38	36	36	35	34
		HL		*Max*	58	58	58	57	56	54	53	51	49	46	44	42	41	40	40
				Min	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29
xi)	41Cr2Ni2Mo2 41Cr2Ni2Mo2 S3	HH	850	*Max*	60	60	60	59	58	57	55	54	48	42	40	38	37	37	36
				Min	55	55	55	53	51	47	44	41	36	33	31	29	28	28	27
		HL		*Max*	58	58	57	56	54	52	49	48	42	37	35	34	33	33	32
				Min	53	53	52	50	47	42	38	35	30	28	26	25	24	24	23
xii)	34Cr6Ni6Mo2	HH	850	*Max*	58	58	58	58	57	57	57	57	57	57	57	57	57	57	57
				Min	53	53	53	53	52	51	51	51	51	50	50	50	50	49	48
		HL		*Max*	55	55	55	55	54	54	54	54	54	54	54	54	53	53	53
				Min	50	50	50	50	49	48	48	48	48	47	47	47	46	45	44

a This table is not applicable to steels ordered with a restricted range of carbon content, *see* footnote c) in Table C.2.

Table C.12 Maximum Diameter for which at Least 90% Martensite shall be Attained in the Core Hardness Test (CH Grades)

(*Clauses* 8.2.4, 8.2.6 *and* 9.3)

Sl No.	Steel Designation	Symbol	Austenitizing temperature in the core hardening test[a] °C ± 5°C	Minimum core hardness (90% martensite structure) HRC	Maximum diameter to ensure 90% of martensite in the core[b] mm
(1)	(2)	(3)	(4)	(5)	(6)
Steels without boron					
i)	37Mo2	CH	850	48	8
ii)	38Cr2	CH	850	48	8
iii)	46Cr2	CH	850	51	9
iv)	34Cr4	CH	850	46	14
v)	37Cr4	CH	850	48	15
vi)	40Cr4	CH	850	50	16
vii)	41Cr4S3	CH	850	50	16
viii)	25Cr4Mo2	CH	850	41	13
ix)	25Cr4Mo2S3	CH	850	41	13
x)	34Cr4Mo2	CH	850	45	18
xi)	37Cr4Mo2	CH	850	48	18
xii)	42Cr4Mo2	CH	850	50	21
xiii)	42Cr4Mo2S3	CH	850	50	21
xiv)	34Cr6Ni6Mo2	CH	850	46	31
xv)	41Ni7Cr3Mo2	CH	850	50	34
xvi)	35C8	CH	840-880	40	8
xvii)	40C8	CH	830-860	40	11
xviii)	45C8	CH	830-860	40	12
xix)	37C15	CH	820-850	40	15
xx)	40Cr4Mo3	CH	850-880	48	28
Boron alloyed steel grades					
xxi)	17C8BT	CH	900	37	9
xxii)	23C8BT	CH	890	40	9
xxiii)	28C8BT	CH	880	43	10
xxiv)	33C8BT	CH	870	45	11
xxv)	38C8BT	CH	860	48	11
xxvi)	23Cr1BT	CH	880	42	14
xxvii)	17C10BT	CH	890	37	12
xxviii)	20C10BT	CH	880	39	14
xxix)	21C10BT	CH	880	40	12
xxx)	23C10BT	CH	880	42	14
xxxi)	27C10BT	CH	870	43	14
xxxii)	26C10BT	CH	880	40	16
xxxiii)	30C10BT	CH	860	44	14
xxxiv)	36C10BT	CH	850	47	14
xxxv)	34C14BT	CH	850	40	26
xxxvi)	37C13BT	CH	850	48	16
xxxvii)	30Mo1BT	CH	870	45	18
xxxviii)	32Cr4BT	CH	860	46	30
xxxix)	36Cr4BT	CH	850	48	30
xl)	31Cr2Mo1BT	CH	860	45	30

[a] As a guideline, a hardening time at temperature of at least 30 min is recommended.

[b] The maximum diameters stated are those attainable with the lowest hardenability within each steel grade. Using HH grades the maximum diameter can be increased.

ANNEX D

SUPPLEMENTARY OR SPECIAL REQUIREMENTS

D.1 General

One or more of the following supplementary or special requirements may be agreed upon at the time of enquiry and order. The details of these requirements may be agreed upon between the manufacturer and the purchaser at the time of enquiry and order if necessary.

D.2 Fine Grain Steel

D.2.1 *General*

This requirement is applicable to products covered by Annexes B and C.

D.2.2 *Case Hardening Steels (Annex B)*

Fine grain steel shall have an austenitic grain size number of 5 or finer. If specific testing is ordered, the grain size requirement is to be verified by determining the aluminium content or micrographically. The fine grain structure is normally achieved when the total aluminium content is a minimum of 0.018%. In such cases, micrographic investigation is not necessary. The aluminium content shall be given in the inspection document. Otherwise, one test piece per cast shall be inspected for the determination of the apparent austenitic grain size.

Sampling and sample preparation shall be as specified in IS 4748. The steel shall be tested in accordance with the Mc-Quaid-Ehn method described in IS 4748 and the grain structure shall be considered satisfactory if 70% of the area is within the specified size limits.

Unless otherwise agreed at the time of enquiry and order, the grain size shall be determined from a carburized specimen. Carburization shall be achieved by maintaining the specimen in carburizing powder at (925 ± 10)°C for 6 h. This is generally done by keeping the carburizing chamber at (925 ± 10)°C for 8 h, including a preheating period. In most cases, a carburized layer of approximately 1 mm is obtained. After carburizing, cooling of the specimen at a rate slow enough ensures the cementite precipitating on the grain boundaries of the hypoeutectoid zone of the carburized layer.

D.2.3 *Steels for Quenching and Tempering (Annex C)*

When tested in accordance with IS 4748 the steel shall have an austenitic grain size number of 5 or finer.

If specific testing is ordered, it shall also be agreed whether this grain size requirement is to be verified by determining the aluminium content or micrographically.

In the first case, the fine grain structure is normally achieved when the total aluminium content is a minimum of 0.007%. In such cases, the micrographic investigation is not necessary. The aluminium content shall be given in the inspection document. In the second case, one test piece shall be inspected per cast for the determination of the austenitic grain size.

Sampling and sample preparation shall be as specified in IS 4748. The steel shall be tested in accordance with the Bechet-Beaujard method described in IS 4748 and the grain structure shall be considered satisfactory if 70% of the area is within the specified size limits.

Unless otherwise agreed at the time of enquiry and order, the quenched grain size shall be determined. Hardening shall be carried out under the following conditions for the purposes of determining the quenched grain size:

a) for steels with a lower carbon content limit < 0.35 %: (880 ± 10)°C, 90 min/water; and
b) for steels with a lower carbon content limit ≥ 0.35 %: (850 ± 10)°C, 90 min/water.

In cases of dispute, pretreatment at 1150°C for 30 min/air shall be carried out in order to produce a uniform starting condition.

D.3 Carbide spheroidization

This requirement is applicable to products covered by Annexes A, B and C when ordered in the heat treatment conditions '+ AC', '+ AC + PE', '+ AR + AC', '+ AR + C + AC +', '+ AR + C + AC + LC', '+ AC + C', as defined in Tables A.1, B.1and C.1.

NOTE — As the carbon content decreases it becomes more difficult to obtain spheroidized cementite.

The cross-section of each test piece shall be prepared, polished and then etched by means of a suitable solution.

The degree of spheroidization of cementite shall be verified by means of a microscopic examination of the section, normally with a magnification of X 500.

Degree of spherodization shall be mutually agreed between the purchaser and the manufacturer.

If so agreed at the time of ordering, the degree of spheroidization shall be assessed with reference to an agreed series of standard images.

D.4 Non-Metallic Inclusion Content

This requirement is applicable to products covered by Annexes B and C.

NOTE — The requirements for non-metallic inclusion content apply in every case. However, proof requires a special agreement.

If there is a special agreement at the time of enquiry and order, the microscopic non-metallic inclusion content shall be determined to an agreed procedure and within agreed limits. If there is no agreement concerning the method and the limits at the time of enquiry and order, the content of non-metallic inclusions shall be determined in accordance with IS 4163, method A and the criteria in Table 2.

D.5 Special Limits for Decarburization and Testing for Decarburization

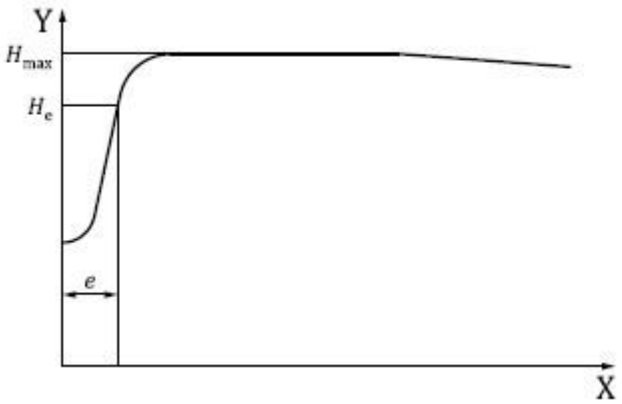
This requirement is applicable to products covered by Annexes B and C.

Values below those indicated in **15** for partial decarburization can be agreed at the time of enquiry and order. Testing for decarburization shall be carried out in accordance with IS 6396 with the following exceptions.

Decarburization is inspected by a microscope on a transverse metallographic test piece suitably etched, with a magnification of X 200.

The depth of decarburization of the sample is considered as being the average of eight measurements at the ends of four diameters located at 45° to each other, starting from the zone of maximum decarburization and avoiding starting from a defective zone. In the calculation of the above average value, any measuring point of the seven remaining situated in a local

surface defect shall not be taken into account in the calculation. In cases of dispute, the depth of decarburization shall be determined by micro-hardness measurements (HV 0.3) along four diameters located at 45° to each other, on test pieces submitted to quenching conforming to the indications given in the various tables regarding hardenability test. The depth of decarburization is considered as being the average of the eight values e1, e2 …e8, which correspond to the distances between the surface and the nearest point on the hardness curve for which the hardness value is found to be equal to 80% of the maximum hardness value in the zone adjacent to the decarburized zone (*see* Fig. D.1). Any measuring point situated in a local surface defect shall not be taken into consideration.



Key

*H*e *H*e = 0.80 *H*max
X distance from surface, in mm
Y hardness HV 0.3

FIG. D.1 DETERMINATION OF THE DEPTH OF DECARBURIZATION

ANNEX E
(*Clause* 5.2)

DESIGNATION OF STEELS GIVEN IN ANNEXES A, B, C AND THE COMPARABLE GRADES COVERED IN VARIOUS DESIGNATION SYSTEMS

Table E.1 Designation of Steels given in this Document and the Comparable Grades Covered in Various Designation Systems

Steel grades in accordance with											General Industry equivalent
IS Steel designation	ISO 4954	ASTM/ SAE/UNS[a]		EN 10263[b]			JIS[c]		GB/ISC[d]		
						i/n/ we		i/n/ we		i/n/ we	
Non-alloy steels not intended for heat treatment after cold working											
2C3	C2C	AISI 1002	—	C2C	1.0314	i	SWRCH6A	—	—	—	
4C3	C4C	AISI 1004	—	C4C	1.0303	i	SWRCH6A	—	—	—	
5C4	-	AISI 1005				i					
8C3	C8C	AISI 1008	—	C8C	1.0213	i	SWRCH8A	—	—	—	
10C4C	C10C	AISI 1010	—	C10C	1.0214	i	SWRCH10A	—	—	—	
10C4GC	C10GC	-	—	—	—	—	SWRCH10K	—	—	—	
14C6	-	AISI 1014									
15C4C	C15C	AISI 1015	—	C15C	1.0234	i	SWRCH15A	—	—	—	
15C4GC	C15GC	-	—	—	—	—	SWRCH15K	—	—	—	
17C8C	C17C	AISI 1017	—	C17C	1.0434	i	SWRCH18A	—	—	—	
17C8GC	C17GC	-	—	—	—	—	SWRCH18K	—	—	—	
20C8C	C20C	AISI 1020	—	C20C	1.0411	i	SWRCH22A	—	—	—	
20C8GC	C20GC	-	—	—	—	—	SWRCH22K	—	—	—	
25C9C	C25C	AISI 1025	—	—	—	—	—	—	—	—	
25C9GC	C25GC	-	—	—	—	—	—	—	—	—	
Non-alloy cold heading and cold extruding case hardening steels											
10C4GC	C10E2C		—	C10E2C	1.1122	i	—	—	—	—	
15C4GC	C15E2C		—	C15E2C	1.1132	i	—	—	—	—	
17C8GC	C17E2C		—	C17E2C	1.1147	i	—	—	—	—	
20C4GC	C20E2C		—	C20E2C	1.1152	i	—	—	—	—	
Alloy cold heading and cold extruding case hardening steels											
18C10BT	18MnB4	—	—	18MnB4	1.5521	i	—	—	—	—	
22C10BT	22MnB4	—	—	22MnB4	1.5522	i	—	—	—	—	
16Cr4	17Cr3	—	—	17Cr3	1.7013	i	—	—	—	—	
16Cr4S3	17CrS3	—	—	17CrS3	1.7014	i	SCR415HRCH	n	—	—	

Table E.1 (*Continued*)

20Cr4	20Cr4	—	—	20Cr4	1.7027	**i**	H	n	—	—	
20Cr4S3	20CrS4	—	—	20CrS4	1.7028	**i**	—	—	—	—	
16Mn5Cr5	16MnCr5	—	—	16MnCr5	1.7131	**i**	16MnCr5	—	16CrMnH	i	
16Mn5Cr5S3	16MnCrS5	—	—	16MnCrS5	1.7139	i	16MnCrS5	—	—	—	
16Mn5Cr5BT	16MnCrB5			16MnCrB5	1.7160				15CrMn-BH	N	
20Mn5Cr5	20MnCr5						20MnCr5				
20Mn5Cr5S3	20MnCrS5	—	—	20MnCrS5	1.7149	i	20MnCrS5	—	—	—	
12Cr4Mo2	12CrMo4	—	—	12CrMo4	1.7201	i	SCM 415	—	—	—	
18Cr4Mo2	18CrMo4	—	—	18CrMo4	1.7243	i	SCM 420	—	—	—	
18Cr4Mo2S3	18CrMoS4	—	—	18CrMoS4	1.7244	i	—	—	—	—	
20Mo5Cr2	20MoCr4	—	—	20MoCr4	1.7321	i	—	—	—	—	
20Mo5Cr2S3	20MoCrS4	—	—	20MoCrS4	1.7323	i	—	—	—	—	
10Ni5Cr4	10NiCr5-4	—	—	10NiCr5-4	1.5905	i	—	—	—	—	
12Ni3Cr2	12NiCr3-2	—	—	12NiCr3-2	1.5701	i	—	—	—	—	
17Ni6Cr6	17CrNi6-6	—	—	17CrNi6-6	1.5918	i	—	—	—	—	
20Ni2Cr2Mo2	20NiCrMo2-2	—	—	20NiCrMo2-2	1.6523	i	SNCM220 SNCM220H	n	20CrNi-MoH	i	
20Ni2Cr2Mo2S3	20NiCrMoS2-2	—	—	20NiCrMoS2-2	1.6526	i	—	—	—	—	
20Ni8Cr2Mo3	20NiCrMo7	—	—	20NiCrMo7	1.3576	i	SNC-M420HRCH	—	—	—	
20Ni6Cr3Mo3S3	20NiCrMoS6-4	—	—	20NiCrMoS6-4	1.6571	i	—	—	—	—	
21Ni2Cr2Mo2		SAE 8620									
17Ni2Cr2Mo2		SAE 8617									
20Ni2Cr2Mo3		SAE 8720									
20C10BT		19MnB4			1.5523 (EN 10269)						
Non-alloy cold heading and cold extruding steels for quenching and tempering											
30C7	C30EC	—	—	C30EC	—	i	SWRCH30K	i	—	—	
35C7	C35EC	—	—	C35EC	1.1172	i	—	—	—	—	

Table E.1 (*Continued*)

35C7S3	C35RC	—	—	C35RC	1.1060	i	—	—	—	—	
40C8	-	-		EN8D	-	-	CK45				EN8D/CK45
45C7	C45EC	—	—	C45EC	1.1192	i	—	—	—	—	
45C7S3	C45RC	—	—	C45RC	1.1061	i	—	—	—	—	
30C7S3	C30RC										

Steel grades in accordance with											
IS Steel Designation	**ISO number**	**ASTM/ SAE/UNS[a]**		**EN 10263[b]**			**JIS[c]**		**GB/ISC[d]**		**General Industry equivalent**
			i/n/ we			**i/n/ we**		**i/n/ we**		**i/n/ we**	
Alloy cold heading and cold extruding steels for quenching and tempering											
37Mo2	37Mo2	—	—	37Mo2	1.5418	i	—	—	—	—	
38Cr2	38Cr2	—	—	38Cr2	1.7003	i	—	—	—	—	
46Cr2	46Cr2	—	—	46Cr2	1.7006	i	—	—	—	—	
34Cr4	34Cr4	—	—	34Cr4	1.7033	i	SCr435/ SCr435H	N	—	—	
37Cr4	37Cr4	—	—	37Cr4	1.7034	i	—	—	—	—	
40Cr4	41Cr4	—	—	41Cr4	1.7035	i	SCr440 SCr440H	N	—	—	
25Cr4Mo2	25CrMo4	—	—	25CrMo4	1.7218	i	SCM425/ SCM425H	N	—	—	
25Cr4Mo2S3	25CrMoS4	—	—	25CrMoS4	1.7213	i	—	—	—	—	
34Cr4Mo2	34CrMo4	—	—	34CrMo4	1.7220	i	SCM435/ SCM435H	N	—	—	
37Cr4Mo2	37CrMo4	—	—	37CrMo4	1.7202	i	—	—	—	—	
40Cr4Mo3	42CrMo4	—	—	42CrMo4	1.7225	i	SCM440/ SCM440H	N	—	—	
42Cr4Mo2S3	42CrMoS4	—	—	42CrMoS4	1.7227	i	—	—	—	—	
41Cr2Ni2Mo2	41CrNiMo2	—	—	41CrNiMo2	1.6584	—	SNCM240	n	—	—	
41Cr2Ni2Mo2S3	41CrNiMoS2	—	—	41CrNiMoS2	1.6588	—	—	—	—	—	
34Cr6Ni6Mo2	34CrNiMo6	—	—	34CrNiMo6	1.6582	i	—	—	—	—	
41Ni7Cr3Mo2	41NiCrMo7-3-2	—	—	41NiCrMo7-3-2	1.6563	i	—	—	—	—	
41Cr4S3	41CrS4	—	—	41CrS4	1.7039	i	—	—	—	—	
41Cr3		SAE 5140	i				41Cr4				
40C15		SAE	i								

Table E.1 (*Continued*)

		1541									
40Cr4Mo2		SAE 4140	i				SCM 440/ SCM440H				
35Cr4Mo2		SAE 4135	i				SCM 435/ SCM435H				
Alloy cold heading and cold extruding steels for quenching and tempering with boron											
17C8BT	17B2	—	—	17B2	1.5502	i	—	—	—	—	
23C8BT	23B2	—	—	23B2	1.5508	i	—	—	—	—	
28C8BT	28B2	—	—	28B2	1.5510	i	—	—	—	—	
33C8BT	33B2	—	—	33B2	1.5514	i	—	—	—	—	
38C8BT	38B2	—	—	38B2	1.5515	i	—	—	—	—	
23Cr1BT	23MnB3	—	—	23MnB3	1.5507	i	—	—	—	—	
17C10BT	17MnB4	—	—	17MnB4	1.5520	i	—	—	—	—	
20C10BT	20MnB4	—	—	20MnB4	1.5525	i	—	—	—	—	
23C10BT	23MnB4	—	—	23MnB4	1.5535	i	—	—	—	—	
27C10BT	27MnB4	—	—	36MnB4	1.5536	i	—	—	—	—	
30C10BT	30MnB4	—	—	20MnB5	1.5526	i	—	—	—	—	
36C10BT	36MnB4	—	—	36MnB4	1.5537	i	—	—	—	—	
20C13BT	20MnB5	—	—	20MnB5	—	—	SWRCHB620	—	—	—	
23C13BT	23MnB5	—	—	23MnB5	—	—	SWRCHB620	—	—	—	
26C13BT	26MnB5	—	—	26MnB5	—	—	SWRCHB620	—	—	—	
Alloy cold heading and cold extruding steels for quenching and tempering with boron											
35C14BT	34MnB5	—	—	34MnB5	—	—	SWRCHB620	—	—	—	
37C13BT	37MnB5	—	—	37MnB5	1.5538	i	—	—	—	—	
30Mo1BT	30MoB1	—	—	30MoB1	1.5408	i	—	—	—	—	
32Cr4BT	32CrB4			32CrB4	1.7076	i	—	—	—	—	
36Cr4BT	36CrB4			36CrB4	17077	i	—	—	—	—	
31Cr2Mo1BT	31CrMoB2-1			31CrMoB2-1	1.7272	i	—	—	—	—	
21C8BT		10B21	i								
22C9BT		10B22	i								
23C5BT		10B23	i								
26C9BT		15B25	i								

Table E.1 (*Concluded*)

21C13BT		15B21	i								
25C5BT		10B33	i								
33C9BT		10B33	i								
35C7BT		10B34	i								
35C8BT		10B35	i								
40C15BT		15B41	i								

[a] US steel listed in ASTM A959 and in UNS. If the steel number is given in brackets, then the steel only has a UNS number.

[b] European steel listed in EN 10263 and in the “Stahl-Eisen-Liste”. If the steel number is given in brackets, then the steel is only listed in the “Stahl- Eisen-Liste”.

[c] Japanese Industrial Standard.

[d] Chinese National Standard.

[e] i= identical steel to ISO steel grade, n = steel grade with closer match of composition, but not identical, w = wider match.

ANNEX F
(*Foreword*)

COMMITTEE COMPOSITION

Alloy Steels and Forgings Sectional Committee, MTD 16

Organization	*Representative(s)*
Mishra Dhatu Nigam Limited, Midhani, Hyderabad	SHRI T. MUTHUKUMAR (***Chairperson***)
Bharat Heavy Electrical Limited, New Delhi	SHRI VENKATESWARLU ALA SHRI MANU SANKAR HARISH (*Alternate*)
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Sundram Fasteners Limited, Chennai	SHRI ATUL KUMAR AGARWAL
	DR P. SHANMUGAM (*Alternate*)
Tata Steel Limited, Jamshedpur	DR T. BHASKAR
	DR PRATEEK MALLICK (*Alternate*)
IGCAR	SHRI UTPAL BORAH
RITES	SHRI SANDEEP GUPTA
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This Indian Standard has been developed from Doc No.: MTD 16 (15742).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi