IS 5517 (1993): Steels for Hardening and Tempering [MTD 16: Alloy Steels and Forgings]

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IS 5517 : 1993
(Reaffirmed 1998)

भारतीय मानक

कठोरण एवं पायनन के लिए इस्पात — विशिष्ट

(दूसरा पुनरीक्षण)

Indian Standard

STEELS FOR HARDENING AND TEMPERING — SPECIFICATION

(Second Revision)

Second Reprint JUNE 2001

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

November 1993

Price Group 6

Alloy Steels and Special Steels Sectional Committee, MTD 16

FOREWORD

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

This standard was first published in 1969 and revised in 1978. On the basis of experience gained in the production and use of steels, it has been decided to revise the standard again. The following major modifications have been incorporated in this revision:

A few new grades such as, 42CrV6, 50Cr4V2, 58Cr4V1, 49MnVS3, 37Mn5Si5, 55Si6Cr3 and 45CrSi9 have been introduced.

Carbon and Molybdenum content in 40Cr4Mo3 grade have been limited to make it cost effective and better responsive to induction hardening.

The revision has been carried to make the specification more quality-oriented for which a few tests such as, step down test, blue fracture test, magnetic particle test, etc, have been introduced.

Many new clauses have been introduced and existing clauses suitably modified to make the standard complete in itself.

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

AMENDMENT NO. 2 AUGUST 2006
TO
IS 5517 : 1993 STEEL FOR HARDENING AND TAMPERING — SPECIFICATION

(Second Revision)

(*Page* 10, *Table* 5, *Steel Designation* '25Cr15Mo6', *col* 2, *row* 5) — Substitute '1 540 *Min*' *for* '1 500 *Min*'

(*Page* 10, *Table* 5, *Steel Designation* '25Cr15Mo6', *col* 3, *row* 5) — Substitute '1 240' *for* '1 300'

(*Page* 10, *Table* 5, *Steel Designation* '40Ni6Cr4Mo3', *col* 2, *row* 5) — Substitute '1200 to 1350' *for* '1200 to 1250'.

(*Page* 10, *Table* 5, *Grade* 40Ni6Cr4Mo3, *col* 2, *row* 6) — Substitute '1 550' *for* '1 500'

(*Page* 11, *Table* 5, *Steel Designation* '30Ni10Cr3Mo6') — Substitute '31Ni10Cr3Mo6' *for* '30Ni10Cr3Mo6.

(*Page* 11, *Table* 6, *col heading* 3) — Substitute '*Max*' *for* '*Min*'

(*Page* 12, *Table* 6, *Grade* 55Cr3, *col* 3) — Substitute '250' *for* '250 *Max*'

(*Page* 12, *Table* 6, *Grade* 40Ni14, *col* 3) — Substitute '250' *for* '250 *Max*'

(*Page* 12, *Table* 6, *Steel Designation* '40Ni16Cr4Mo2') — Substitute '40Ni6Cr4Mo2' *for* '40Ni16Cr4M02'.

(*Page* 12, *Table* 6, *Steel Designation* '40Ni16Cr4Mo3') — Substitute '40Ni6Cr4Mo3' *for* '40Ni16Cr4Mo3'

(MTD 16)

Reprography Unit, BIS, New Delhi, India

AMENDMENT NO. 1 AUGUST 1999
TO
IS 5517 : 1993 STEELS FOR HARDENING AND TEMPERING — SPECIFICATION

(Second Revision)

(*Foreword, para* 2, *line* 4) — Substitute '42Cr6V1' *for* '42CrV6'.

(*Page* 4, *Table* 2, *col* 3, *row* 31 *and* 32) — Substitute '0.40 to 0.70' *for* '0.40 to 0.90' for grade 30Ni13Cr5.

(*Page* 8, *Table* 4, *col* 1, *row* 21) — Substitute '42Cr6V1' *for* '42CrV6'.

(*Page* 10, *Table* 5, *col* 1, *row* 1) — Substitute '50Cr4V2' *for* '55Cr4V2'.

(*Page* 10, *Table* 5, *col* 1, *row* 9) — Substitute '42Cr6V1' *for* '42CrV6'.

(*Page* 10, *Table* 5, *col* 1, *row* 28) — Substitute '25Cr13Mo6' *for* '25Cr15Mo6'.

(*Page* 11, *Table* 5, *col* 2, *row* 5) — Substitute '1 200-1 250' *for* '1 200-1 350'

(*Page* 11, *Table* 5, *col* 1, *row* 7) — Substitute '31Ni10Cr3Mo6' *for* '40Ni10Cr3Mo6'.

(*Page* 11, *Table* 5, *Note* 2, *line* 2) — Substitute '1 kgf/mm^2 = 9.81 N/mm^2' *for* '1 Kgf/mm^2 = 9.91 N/mm^2'.

(*Page* 11, *Table* 6, *col* 1, *row* 15) — Substitute '42Cr6V1' *for* '42CrV6'.

(*Page* 11, *Table* 6, *col* 1, *row* 30) — Substitute '30Ni13Cr5' *for* '30Ni13Cr2'.

(MTD 16)

Reprography Unit, BIS, New Delhi, India

Indian Standard

STEELS FOR HARDENING AND TEMPERING — SPECIFICATION

(Second Revision)

1 SCOPE

1.1 This standard covers the technical and delivery requirements for wrought alloyed and unalloyed steels in the form of bars, rods, flats, plates, forgings, etc, to be used in the hardened and tempered condition.

1.2 The steels covered by this standard are in general intended for forgings and machining of parts for engineering or automobile purposes.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
228	Methods of chemical analysis of steels (*second revision*)
1500 : 1983	Brinell hardness test for metallic materials (*second revision*)
1598 : 1977	Izod impact test for metals (*first revision*)
1608 : 1972	Tensile testing of steel products (*first revision*)
2049 : 1978	Colour code for the identification of wrought steels for general engineering purposes
3469 : (Parts 1 to 3) 1974	Tolerances for closed die steel forging (*first revision*)
3664 : 1981	Code of practice for ultrasonic pulse echo testing by contact and immersion methods (*first revision*)
3711 : 1966	Selection and preparation of samples and test pieces for mechanical test for wrought steel
3739 : 1987	Dimensional tolerances for carbon and alloy constructional steel products (*first revision*)
3848 : 1981	End quench test for harden ability of steel (*first revision*)
4163 : 1982	Method for determination of inclusion content in steel by macroscopic method (*first revision*)
4748 : 1968	Method for estimating average grain size of metals (*first revision*)
8910 : 1978	General technical delivery requirements for steel and steel products
10138	Macroscopic method for determination of non-metallic inclusion content in wrought steel·
(Part 1) : 1982	Blue fracture test method
(Part 2) : 1983	Step machined test method
(Part 3) : 1983	Magnetic particle inspection method

3 SUPPLY OF MATERIAL

3.1 General requirements relating to the supply of material shall conform to IS 8910 : 1978.

3.2 Steels covered by this standard shall be ordered and delivered in any one of the basis given in Table1.

3.3 The particulars to be specified by the purchaser while ordering for steels covered by this specification should be as given below:

a) Grade,

b) Delivery condition,

c) Size,

d) Finish,

e) Test requirement,

f) Special requirements, such as bundling and packing, and

g) Test report, if required.

Table 1 Delivery Condition for Ordering of Steels

(*Clause* 3 2)

Requirements	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1 Chemical composition	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
2 Hardenability (jominy)					×	×	×	×									×	×	×			
3 Hardness																						
Maximum value as annealed		×				×					×			×			×			×		
Maximum value as treated for improved machinability			×				×					×			×			×			×	
Maximum value as rolled/forged				×				×					×			×			×			×
4. Mechanical properties										×	×	×	×									
5 Special cleanliness test																						
Step down test/ Blue fracture test													×	×	×	×	×	×	×	×	×	
6 Crack testing (Magnetic particle)																				×	×	×

NOTES

1 Other modes of deliveries if justified by the quality requirements of the parts either for manufacturing or for end use can be specially agreed to at the time of enquiry and order

2 For modes of deliveries with hardenability/mechanical properties guarantee minor variation from chemical composition from Table 2 is permissible

3 For closer bands of hardenability and acceptance level of cleanliness by step down test, agreement should be made at the time of enquiry and order

4 Cleanliness rating by step down test/Blue fracture test is not applicable to free cutting steel

4 MANUFACTURE

4.1 Unless otherwise agreed to in the order, the processess used in making the steel and the product shall be left to the discretion of the manufacturer, but the steel shall be fully killed When so desired, the purchaser shall be informed of the steel making process

However, for continuously cast steels and for steels in specially treated condition, like Electro-flux refined, Vacuum degassed, Secondary refined, etc, the steel making process should be agreed to at the time of enquiry and order

For continuously cast bar/billets, a minimum reduction ratio of 6 1 between the cast product and the final product is recommended However other reduction ratios may be mutually agreed upon between the manufacturer and the purchaser at the time of enquiry and order

4.2 The steels may be made by agreement with the addition of micro alloying elements like Titanium, Niobium Vanadium, Boron, etc, either individually or in combination

4.3 Sufficient reduction and discard shall be made to ensure freedom from piping, harmful segregation, etc, as assessed by macroetching and/or ultrasonic testing The acceptance standard shall be mutually agreed upon at the time of enquiry and order

5 FREEDOM FROM DEFECTS

5.1 The material shall be free from such surface and internal defects which may impair the end use

The method of evaluating surface and internal defects and their allowable limits shall be mutually agreed to at the time of enquiry and order

5.2 Removal of surface defects, by appropriate means, shall be permitted provided that the remaining dimensions, after defect removal is not less than specified at any point of the bar or billet etc, and that the operation is not likely to affect the processing of the material Removal of surface defects beyond this level may be permitted only on approval of the purchaser

6 CHEMICAL COMPOSITION

6.1 The ladle analysis of steels shall be as given in Table 2 The analysis of steels shall be carried out either by the method specified in IS 228 and its relevant parts or any other established instrumental/ chemical method.

In case of any dispute the procedure given in IS 228 and its relevant parts shall be referee method However, where method is not given in IS 228 and its relevant parts, the referee method shall be as agreed to between the purchaser and the manufacturer

6.2 Check Analysis

The check analysis shall be carried out on the finished product The permissible variation of the check analysis for the limit specified in Table 2 shall be as given in Table 3

6.3 Elements not specified in Table 2 shall not be added to the steels except where agreed to, other than for the purpose of finishing the heat, and shall not exceed the following limits, if present

Constituent	*Percent, Max*
Chromium	0 25
Nickel	0 25
Copper	0 35
Vanadium	0 05
Molybdenum	0 05
Boron	0 (X)0 3
Tin	0 05

NOTES

1 All reasonable precautions shall be taken to prevent the addition from scrap or other materials used in manufacture of such elements which affect the hardenability, mechanical properties and applicability

2 Trace elements when added together should not exceed 0 8 percent, however, restricted limits could be mutually agreed upon between the manufacturer and the purchaser at the time of enquiry and order

3 % Copper + 10 × (% Tin) shall not exceed 0 60 percent

Table 2 Chemical Composition of Steels for Hardening and Tempering

(*Clauses* 6 1, 6 2, 6 3, 11 2 *and* 15 1)

Steel Designation	Constituent, Percent									
	C	Mn	Si	Ni	Cr	Mo	V	Al	S	P
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
									Max	*Max*
30C8	0 25 to 0 35	0 60 to 0 90	0 10 to 0 35	—	—	—	—	—	035	035
35C8	0 30 to 0 40	0 60 to 0 90	0 10 to 0 35	—	—	—	—	—	035	035
40C8	0 35 to 0 45	0 60 to 0 90	0 10 to 0 35	—	—	—	—	—	035	035
45C8	0 40 to 0 50	0 60 to 0 90	0 10 to 0 35	—	—	—	—	—	035	035
50C8	0 45 to 0 55	0 60 to 0 90	0 10 to 0 35	—	—	—	—	—	035	035
55C8	0 50 to 0 60	0 60 to 0 90	0 10 to 0 35	—	—	—	—	—	035	035
40C10S18	0 35 to 0 45	0 80 to 1 20	0 25 *Max*	—	—	—	—	—	0 14 to 0 22	0 060
40C15S12	0 35 to 0 45	1 30 to 1 70	0 25 *Max*	—	—	—	—	—	0 08 to 0 15	
20C15	0 16 to 0 24	1 30 to 1 70	0 10 to 0 35	—	—	—	—	—	035	035
27C15	0 22 to 0 32	1 30 to 1 70	0 10 to 0 35	—	—	—	—	—	035	035
37C15	0 32 to 0.42	1 30 to 1 70	0 10 to 0 35	—	—	—	—	—	035	035
35Mn6Mo3	0 30 to 0 40	1 30 to 1 80	0 10 to 0 35	—	—	0 20 to 0 35	—	—	035	035
35Mn6Mo4	0 30 to 0 40	1 30 to 1 80	0 10 to 0 35	—	—	0 35 to 0 55	—	—	035	035
37Mn5Si5	0 33 to 0 41	1 10 to 1 40	0 10 to 1 40	—	—	—	—	—	035	035

Table 2 (*Concluded*)

Steel Designation	Constituent, Percent									
(1)	C (2)	Mn (3)	Si (4)	Ni (5)	Cr (6)	Mo (7)	V (8)	Al (9)	S (10)	P (11)
									Max	*Max*
42Cr6V1	0.37 to 0.47	0.50 to 0.80	0.15 to 0.35	—	1.40 to 1.70	—	0.07 to 0.12	—	.035	.035
45CrSi9	0.40 to 0.50	0.30 to 0.60	2.75 to 3.25	—	8.50 to 9.50	—	—	—	.035	.035
46V1S3	0.42 to 0.50	0.60 to 1.00	0.60 *Max*	—	—	—	0.08 to 0.13	—	0.045 to 0.065	.035
58Cr4V1	0.53 to 0.63	0.80 to 1.10	0.15 to 0.5	—	0.90 to 1.20	—	0.07 to 0.12	—	.035	.035
50Cr4V2	0.45 to 0.55	0.70 to 1.10	0.15 to 0.40	—	0.90 to 1.20	—	0.10 to 0.20	—	.035	.035
55Cr3	0.50 to 0.60	0.60 to 0.80	0.10 to 0.35	—	0.60 to 0.80	—	—	—	.035	.035
55Si6Cr3	0.50 to 0.60	0.50 to 0.80	1.20 to 1.60	—	0.50 to 0.80	—	—	—	.035	.035
40Cr4	0.35 to 0.45	0.60 to 0.90	0.10 to 0.35	—	0.90 to 1.20	—	—	—	.035	.035
42Cr4Mo2	0.38 to 0.45	0.60 to 0.90	0.10 to 0.35	—	0.90 to 1.20	0.15 to 0.30	—	—	.035	.035
15Cr13Mo6	0.10 to 0.20	0.40 to 0.70	0.10 to 0.35	—	2.90 to 3.40	0.45 to 0.65	—	—	.035	.035
25Cr13Mo6	0.20 to 0.30	0.40 to 0.70	0.10 to 0.35	—	2.90 to 3.40	0.45 to 0.65	—	—	.035	.035
40Cr13Mo10V2	0.35 to 0.45	0.40 to 0.70	0.10 to 0.35	—	3.00 to 3.50	0.90 to 1.10	0.15 to 0.25	—	.035	.035
40Cr7Al10Mo2	0.35 to 0.45	0.40 to 0.70	0.10 to 0.35	—	1.50 to 1.80	0.10 to 0.25	—	0.90 to 1.30	.035	.035
40Ni14	0.35 to 0.45	0.50 to 0.80	0.10 to 0.35	3.20 to 3.60	0.30 *Max*	—	—	—	.035	.035
35Ni5Cr2	0.30 to 0.40	0.60 to 0.90	0.10 to 0.35	1.00 to 1.50	0.45 to 0.75	—	—	—	.035	.035
30Ni13Cr5	0.26 to 0.34	0.40 to 0.90	0.10 to 0.35	3.90 to 4.30	1.00 to 1.40	—	—	—	.035	.035
40Ni6Cr4Mo2	0.35 to 0.45	0.40 to 0.70	0.10 to 0.35	1.20 to 1.60	0.90 to 1.30	0.10 to 0.20	—	—	.035	.035
40Ni6Cr4Mo3	0.35 to 0.45	0.40 to 0.70	0.10 to 0.35	1.25 to 1.75	0.90 to 1.30	0.20 to 0.35	—	—	.035	.035
31Ni10Cr3Mo6	0.27 to 0.35	0.40 to 0.70	0.10 to 0.35	2.25 to 2.75	0.50 to 0.80	0.40 to 0.70	—	—	.035	.035
40Ni10Cr3Mo6	0.36 to 0.44	0.40 to 0.70	0.10 to 0.35	2.25 to 2.75	0.50 to 0.80	0.40 to 0.70	—	—	.035	.035

NOTES

1 In special cases, it may be desirable that the range of carbon content should be more closely controlled than in the range specified above. When this is necessary, restricted ranges of carbon may be agreed to between the purchaser and the manufacturer.

2 Sulphur in the range of .02 to .035 or any other range may be agreed to between the manufacturer and the purchaser.

3 For direct and single quenched process, fully Al killed, fine grained steel should be used.

Table 3 Permissible Variation in Check Analysis
(*Clause* 6.2)

Element	Permissible Content in Ladle Analysis, Percent	Permissible Variation in Product Analysis, Percent
(1)	(2)	(3)
Carbon	Up to 0 50	± 0.02
	Over 0 50 to 0 63	± 0 03
Silicon	Up to 0 50	± 0.03
Manganese	Up to 1.00	± 0 04
	Over 1 00 up to 1 80	± 0 06
Nickel	Over 1 00 up to 1 75	± 0 05
	Over 2 25 up to 4 30	± 0 07
Chromium	Up to 2 00	± 0 05
	Over 2 00 up to 3 50	± 0 10
Molybdenum	Up to 0 30	± 0 03
	Over 0.30 up to 0 50	± 0 04
	Over 0 50 up to 1 10	± 0 05
Sulphur	Up to 0 065	± 0 005
	Over 0 065 up to 0 22	± 0.03
Phosphorous	Up to 0 060	± 0 005
Vanadium	Up to 0 25	± 0 02
Aluminium	0 90 to 1 30	± 0 10

NOTE – ± means that in one cast the deviation may occur over the value or under the lower value of the specified range in Table 2 not both at the same time

7 HEAT TREATMENT

7.1 Recommended temperature for hot working and heat treatments aimed at controlling the hardness, machinability, shearability, etc, are given in Table 4 for guidance only.

7.2 The mechanical properties in the hardened and tempered conditions for various limiting ruling section are specified in Table 5

7.3 Only steels with inherently fine grain structure may be subjected to direct quench, provided the test bars comply with the mechanical properties specified in Table 5.

8 HARDNESS

8.1 The hardness requirements for steel delivered in the conditions 'as rolled (R)' (for guidance only), annealed to 'maximum hardness (A)' or 'treated to improved machinability (M)' shall be as given in Table 6

8.2 Maximum as rolled hardness for steels for improved cold shearability or the range of hardness for improved machinability, if the values are different from as given in Table 6 shall be mutually at the time of enquiry and order

8.3 Hardness values given in Table 6 shall be determined in accordance with IS 1500 : 1983.

9 MECHANICAL PROPERTIES

9.1 The properties given in Table 5 shall be applicable to test bars taken of rounds in the direciton of rolling fibre, the axis of which corresponds to Fig. 1

9.2 For rectangular sections, the range of equivalent sections shall be as given in Fig. 2

9.3 Methods for determining the mechanical properties specified in Table 5 shall be in accordance with IS 1598 . 1977 and IS 1608 : 1972.

9.4 If required, the mechanical properties of the reference test bars after hardening and tempering in accordance with Table 6 shall conform to the requirements given in Table 5. Values other than specified in Table 5 shall be mutually agreed at the time of enquiry and order.

10 GRAIN SIZE

10.1 Unless otherwise agreed, the steel when tested for grain size in accordance with IS 4748 1988 shall show grain size in the range of 5 to 8 for inherently fine grained steel.

10.2 Steel with grain size outside the range of 5 to 8 (for example, microalloyed steels) may however, be supplied with mutual agreement.

10.3 The grain size shall be considered satisfactory if 70 percent of grains are within the specified limits, but the remaining 30 percent of the grains falling either one size below or above the range and not spreaded at both ends of the range.

11 CLEANLINESS OF THE STEEL

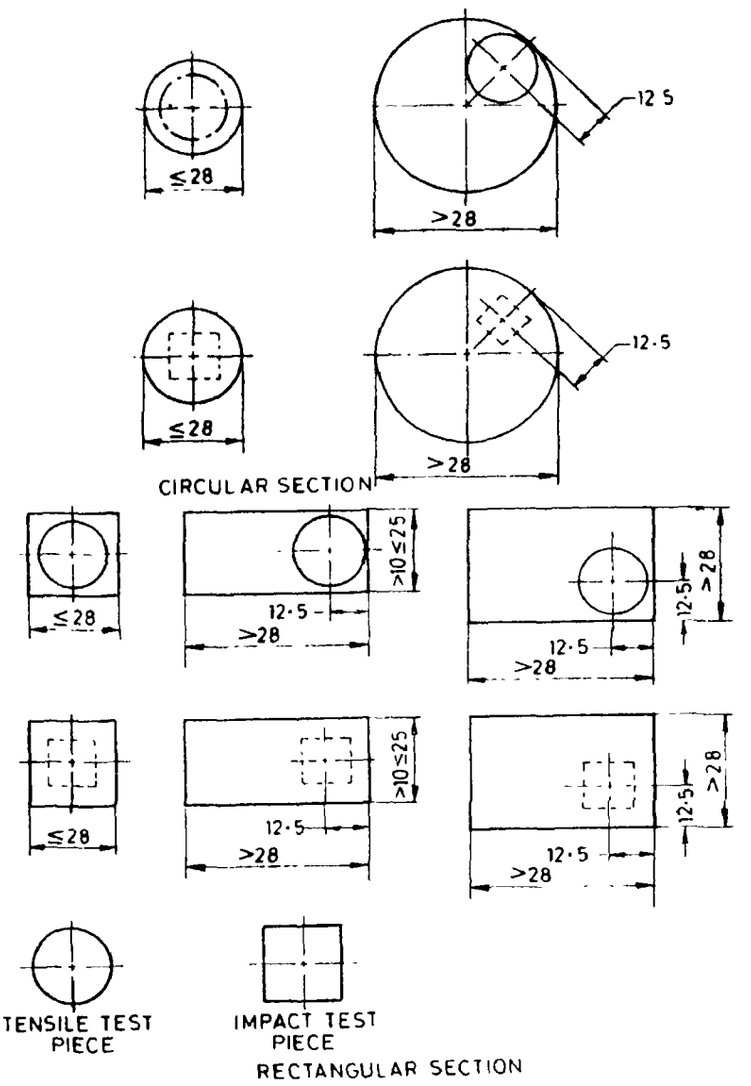
11.1 Inclusion rating of the steel shall be determined in accordance with IS 4163 : 1982. The worst field of each inclusion from each specimen shall be recorded as a rating for the specimen The inclusion rating for the specimen shall not exceed the following limits

a)	For air melted quality	(ABCD 3 *Max)* (thick and thin series)
b)	For vacuum, EFR or Secondary refined steel	The inclusion rating shall be mutually agreed upon at the time of enquiry and order

11.2 When required and ordered, cleanliness of the steel can also be assessed by step down test, Blue fracture test, and magnetic particle tests methods as per IS 10138 (Part 1) : 1982, IS 10138 (Part 2) : 1983 and IS 10138 (Part 3) : 1983 or agreed to at the time of enquiry and order

The acceptance level of non-metallic inclusions shall be, however, mutually agreed keeping in view of the process limitations and end use of the material

The clause is not applicable for free cutting grade of steel as given in Table 2



All dimensions in millimetres.

FIG. 1 LOCATION OF THE TEST PIECES IN THE PRODUCTS TO BE DELIVERED

12 HARDENABILITY

12.1 For steels ordered on the basis of end quench hardenability, the requirements shall be as given in Table 7 or mutually agreed to between the purchaser and the manufacturer.

12.2 The method of testing hardenability of steels shall be in accordance with IS 3848 : 1981

13 DIMENSIONAL TOLERANCES

13.1 The dimensional tolerances for hot rolled steel products shall be in accordance with IS 3739 : 1987 Any additional stipulation on dimensions may be mutually agreed at the time of enquiry and order, if the forging process or the product so calls for.

13.2 For forged steel bars, billets, blooms, etc, the tolerances shall be in accordance with IS 3469 (Parts 1 to 3) : 1974

13.3 Tolerance on Straightness

Unless otherwise agreed to between the purchaser and the manufacturer, the steel shall be supplied in straightened condition with the following limits

Nominal Size/Section	*Maximum Permissible Deviation for Straightness*
40 mm and below	6 mm/metre length
41 mm and above	5 mm/meter length

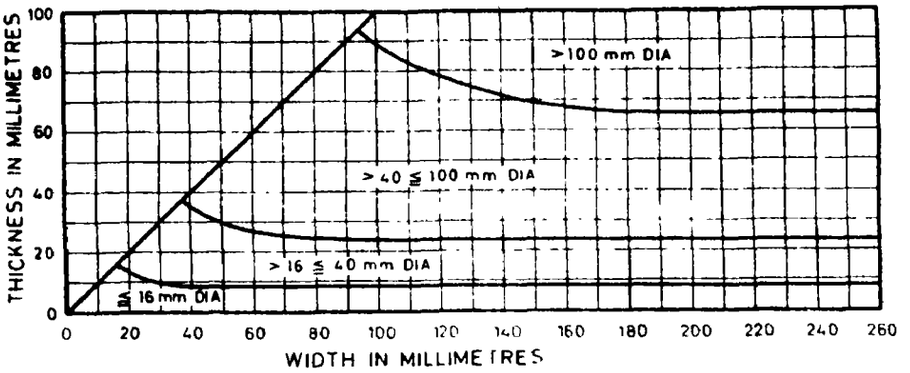


FIG. 2 APPLICABILITY OF THE FIGURES GIVEN IN THE TABLE 5 FOR ROUND SECTION, TO RECTANGULAR SECTION OF OIL OR WATER-QUENCHED PRODUCTS

14 SAMPLING

14.1 Sample for Chemical Analysis

The ladle analysis shall be supplied by the manufacturer. If the product analysis is required by the purchaser at least one sample product shall be taken from each cast.

14.2 Sampling for Hardness in the Normalized or Annealed Condition

14.2.1 One sample product shall be taken from each heat treatment batch for the determination of hardness.

14.3 Sampling for Mechanical Properties

14.3.1 Test pieces for mechanical tests shall be taken in the longitudinal direction of the product in accordance with Fig. 1.

14.4 One sample per cast shall be taken for determination of grain size according to IS 4748 : 1988

14.5 The samples for inclusion rating shall be drawn according to IS 4163 : 1982.

15 RETEST

15.1 Retest for Product Analysis

If the results of the product analaysis do not meet the composition requirements given in Tables 2 and 3, unless otherwise agreed to between the purchaser and the manufacturer, two new samples shall be taken on different pieces from the same cast. Should the two analysis satisfy the requirements, the lot represented shall be accepted. Should either of the tests fail, the material shall be taken as not complying with this standard

15.2 Retest for Hardness Test in the Normalized Annealed Condition

If the sample selected under **14.2** fails to meet the requirements under **8**, two further samples shall be selected from the same heat treatment batch. The consignment shall be considered to conform to the requirements if both the additional tests are satisfactory. Should either of the samples fail, the manufacturer shall have the right, if he so desires, to re-heat-treat the product in any suitable manner before two fresh samples are taken for testing. Should the two tests satisfy the requirements of this standard, the lot represented shall be accepted. Should either of the samples fail, the material shall be taken as not complying with this standard.

15.3 Retest for Mechanical Tests on Test Pieces

If the sample selected under **14.3** fails to meet the requirements under **9**, two further samples shall be selected from the same size grouping for making fresh test bars and tested. The consignment shall be considered to conform to the requirements if both the additional tests are satisfactory. Should either of the test pieces fail, the manufacturer shall have the right, if he so desires to re-heat-treat the lot in any suitable manner before two fresh samples are taken for testing. Should the two tests satisfy the requirements of this standard, the lot represented shall be accepted. Should either of the samples fail, the material shall be taken as not complying with this standard

16 ADDITIONAL TESTS

16.1 If agreed to between the purchaser and the manufacturer at the time of enquiry and order, any or a combination of the following tests may also be carried out to ensure that the steels meet the quality requirements of the purchaser.

a) Macro Etch Test in accordance with IS 11371 : 1985,

b) Ultrasonic Test in accordance with IS 3664 : 1981,

c) Hardenability Test in accordance with IS 3848 : 1981 and values as per Table 7,

d) Blank Hardening Test for core strength guarantee as per recommendations of Table 5,

e) Cleanliness Test as per IS 10138 (Parts 1 to 3) : 1982,

f) Microstructure for machinability, including banding, and

g) *Hot up-set for forgeability.*

16.2 The acceptance level for each or any of these tests shall be mutually agreed to at the time of enquiry and order.

17 MARKING

17.1 All bars of 50 mm dia or equivalent section and above shall be stamped or suitably marked at the end with heat number and name or trade-mark of the manufacturer. Bars of smaller sections shall be tied in suitable bundles which will carry metal tags giving the information.

17.2 The bars, billets, etc, shall be suitably colour coded at the ends to mark the grade of the material. The colour scheme followed can be in accordance with IS 2049 : 1978 or as per purchaser's requirement.

17.3 The material may also be marked with the Standard Mark.

Table 4 Recommended Hardening and Tempering Temperatures for Direct Hardening Steels

(*Clause* 7.1)

Designation	Hot Working Temperature	Normalizing Temperature	Hardening Temperature	Quenching Medium	Tempering Temperature
(1)	(2)	(3)	(4)	(5)	(6)
	°C	°C	°C		°C
30C8	1 200 to 850	860 to 890	860 to 890	Water or Oil	550 to 660
35C8	1 200 to 850	850 to 880	840 to 880	Water or Oil	530 to 660
40C8	1 200 to 850	830 to 860	830 to 860	Water or Oil	550 to 660
45C8	1 200 to 850	830 to 860	830 to 860	Water or Oil	530 to 670
50C8	1 150 to 850	810 to 840	810 to 860	Oil	530 to 660
55C8	1 150 to 850	810 to 840	810 to 840	Oil	550 to 660
40C10S18	1 200 to 850	830 to 860	830 to 860	Oil	550 to 660
40C15S12	1 200 to 850	840 to 870	840 to 870	Oil	550 to 660
20C15	1 200 to 850	860 to 900	860 to 900	Water or Oil	550 to 660
27C15	1 200 to 850	840 to 880	840 to 880	Water or Oil	550 to 660
37C15	1 200 to 850	850 to 870	850 to 870	Water or Oil	550 to 660
35Mn6Mo3	1 200 to 900	—	840 to 860	Water or Oil	550 to 660
35Mn6Mo4	1 200 to 900	—	840 to 860	Oil	550 to 660
37Mn5Si5	1 050 to 850	860 to 890	830 to 850	Water or Oil	530 to 670
55Cr3	1 200 to 850	800 to 850	800 to 850	Oil	500 to 700
55Si6Cr3	1 050 to 850	850 to 880	830 to 860	Oil	430 to 500
40Cr4	1 200 to 850	850 to 880	850 to 880	Oil	550 to 700
42Cr4Mo2	1 200 to 850	850 to 880	850 to 880	Oil	500 to 720
15Cr13Mo6	1 200 to 850	—	890 to 910	Oil	550 to 700[1]
25Cr13Mo6	1 200 to 850	—	890 to 910	Oil	550 to 700[1]
42CrV6	1 100 to 850	850 to 880	830 to 860	Oil	480 to 650
45CrSi9	1 100 to 900	—	1 020 to 1 070	Oil	770 to 820
46V1S3	1 200 to 850	—	—	Oil	—
50Cr4V2	1 050 to 850	840 to 880	830 to 860	Oil	540 to 680
58Cr4V1	1 050 to 850	850 to 880	820 to 850	Oil	480 to 650
40Cr13Mo10V2	1 200 to 850	—	900 to 940	Oil	570 to 650
40Cr7Al10Mo2	1 200 to 850	—	850 to 900	Oil	550 to 700

Table 4 (*concluded*)

Designation	Hot Working Temperature	Normalizing Temperature	Hardening Temperature	Quenching Medium	Tempering Temperature
(1)	(2)	(3)	(4)	(5)	(6)
	°C	°C	°C		°C
40Ni14	1 200 to 850	830 to 860	850 to 860	Oil	550 to 650
35Ni5Cr2	1 200 to 850	—	820 to 850	Water or Oil	550 to 660
30Ni13Cr5	1 200 to 850	—	810 to 830	Air or Oil	250
40Ni6Cr4Mo2	1 200 to 850	—	830 to 850	Oil	550 to 660
40Ni6Cr4Mo3	1 200 to 900	—	830 to 850	Oil	550 to 660 or 150 to 200 (Depending on hardness required)
31Ni10Cr3Mo6	1 200 to 850	—	830 to 850	Oil	Up to 660
40Ni10Cr3Mo6	1 200 to 850	830 to 850	830 to 850	Oil	Up to 660

[1] Stabilization temperature 550°C.

Table 5 Mechanical Properties of Steels in the Hardened and Tempered Condition

(*Clauses* 7.2, 9.1, 9.3 *and* 9.4)

Steel Designation	Tensile Strength MPa	0.2 Percent Proof Stress MPa, *Min*	Elongation 5.65$\sqrt{A}$ Percent, *Min*	Izod Impact Joules, *Min*	Limiting Ruling Section mm
(1)	(2)	(3)	(4)	(5)	(6)
39C8	600 to 750	400	18	55	30
35C8	600 to 750	400	18	55	63
40C8	600 to 750	380	18	41	63
	700 to 850	480	17	35	30
45C8	600 to 750	380	17	41	100
	700 to 850	480	15	35	30
50C8	700 to 850	460	15	—	63
	800 to 950	540	13	—	30
55C8	700 to 850	460	15	—	63
	800 to 950	540	13	—	30
40C10S18	600 to 750	380	18	41	60
	700 to 850	480	17	48	30
40C15S12	700 to 850	500	18	35	60
20C15	600 to 750	440	18	48	30
	700 to 850	500	16	48	15
27C15	600 to 750	440	18	48	63
	700 to 850	500	16	48	30
37C15	600 to 750	440	18	48	100
	700 to 850	540	18	48	63
	800 to 950	600	16	48	30
	900 to 1 050	700	15	41	15
35Mn6Mo3	700 to 850	540	18	55	150
	800 to 950	600	16	55	100
	900 to 1 050	700	15	55	63
	1 000 to 1 150	800	13	48	30
37Mn5Si5	800 to 950	550	14	34	100
	900 to 1050	650	12	27	40
	1000 to 1200	800	11	21	16

Table 5 (*continued*)

Steel Designation	Tensile Strength MPa	0.2 Percent Proof Stress MPa, *Min*	Elongation 5.65/A Percent, *Min*	Izod Impact Joules, *Min*	Limiting Ruling Section mm
(1)	(2)	(3)	(4)	(5)	(6)
55Cr4V2	780 to 980	590	13	34	250
	900 to 1 080	690	12	34	100
	980 to 1180	780	10	34	40
	1 080 to 1 270	880	9	34	16
58Cr4V1	980 to 1 180	735	12	41	250
	1 080 to 1 270	885	10	34	100
	1 180 to 1 370	980	8	27	40
	1 320 to 1 570	1080	7	21	16
42CrV6	740 to 880	540	14	55	160
	880 to 1 030	685	12	48	100
	980 to 1 180	785	11	41	40
	1 080 to 1 270	885	12	34	16
45CrSi9	880 to 1 030	685	10	—	—
35Mn6Mo4	800 to 950	600	16	55	150
	900 to 1 050	700	16	55	100
	1 000 to 1 150	800	15	48	63
55Cr3	900 to 1050	660	12	35	63
	1 000 to 1 150	740	10	17	63
55Si6Cr3	1 400 to 1 600	1200	6	—	16
40Cr4	700 to 850	540	18	55	100
	800 to 950	600	16	55	63
	900 to 1 050	700	15	55	30
42Cr4Mo2	700 to 850	490	13	55	150
	800 to 950	550	12	50	100
	900 to 1 050	650	11	50	63
	1 000 to 1 150	750	10	48	30
15Cr13Mo6	700 to 850	540	18	55	150
25Cr15Mo6	800 to 950	600	16	55	150
	900 to 1 050	700	15	55	150
	1 000 to 1 150	800	13	48	150
	1 100 to 1 250	880	12	41	100
	1 500 *Min*	1300	8	14	63
40Cr13Mo10V2	1 350 *Min*	1120	8	21	63
	1 550 *Min*	1300	8	14	30
40Cr7Al10Mo2	700 to 850	540	18	55	150
	800 to 950	600	16	55	100
	900 to 1050	700	15	48	63
40Ni14	800 to 950	600	16	55	100
	900 to 1050	700	15	55	63
35Ni5Cr2	700 to 850	540	18	55	150
	800 to 950	600	16	55	100
30Ni13Cr5	1 550 *Min*	1300	8	14	63 (air-hardened) 150 (oil-hardened)
40Ni6Cr4Mo2	800 to 950	600	16	55	150
	900 to 1 050	700	15	55	100
	1 000 to 1 150	800	13	48	63
	1 100 to 1 250	880	11	41	30
40Ni6Cr4Mo3	800 to 950	600	16	55	150
	900 to 1 050	700	15	55	150
	1 000 to 1 150	800	13	48	100
	1 100 to 1 250	880	11	41	63
	1 200 to 1 250	1000	10	30	30
	1 500 *Min*	1300	6	11	30
30Ni10Cr3Mo6	900 to 1 050	700	15	55	150
	1 000 to 1 150	800	12	48	150
	1 100 to 1 250	880	11	41	100
	1 200 to 1 350	1000	10	35	63
	1 550 *Min*	1300	8	14	63

Table 5 (*concluded*)

Steel Designation	Tensile Strength MPa	0.2 Percent Proof Stress MPa, *Min*	Elongation 5.65√A Percent, *Min*	Izod Impact Joules, *Min*	Limiting Ruling Section mm
(1)	(2)	(3)	(4)	(5)	(6)
30Ni10Cr3Mo6	900 to 1 050	700	15	55	150
	1 000 to 1 150	800	12	48	150
	1 100 to 1 250	880	11	41	100
	1 200 to 1 350	1000	10	35	63
	1 550 *Min*	1300	8	14	63
40Ni10Cr3Mo6	1 000 to 1 150	800	12	48	150
	1 100 to 1 250	880	11	41	150
	1 200 to 1 350	1000	10	35	150
	1 550 *Min*	1300	8	14	100

NOTES

1 Mechanical properties for steels having a minimum tensile strength of 1 340 MPa and above are given for information only and the delivery condition on the basis of the chemical composition and hardenability shall be applicable in such cases.

2 Izod impact values are for fine grained steels.

1 Kgf/mm² = 9.91 N/mm².

Table 6 Hardeness Requirement for Products Delivered in as Rolled Condition (R), Annealed (A) or Improved Machinability (M)

(*Clause* 8.1)

Steel Grade	As Annealed (A),	As Rolled (R),	Treated for Improved Machinability (M),
	Max	*Min*	*Max*
	HB	HB	HB
30C8	187	240	170
35C8	197	240	183
40C8	207	240	197
45C8	207	240	207
50C8	210	240	217
55C8	220	250	229
40C10S18	200	240	—
40C15S12	200	240	—
20C15	200	240	220
27C15	200	240	223
37C15	220	250	229
35Mn6Mo3	220	250	—
35Mn6Mo4	220	250	—
37Mn5Si5	220	250	220
42CrV6	220	250	—
45CrSi9	240	250	—
46V1S3	220	250	—
50Cr4V2	250	As per agreement	—
58CrV1	250	As per agreement	—
55Cr3	220	25 *Max*	—
55Si6Cr3	220	250	220
40Cr4	241	250	241
42Cr4Mo2	241	250	241
15Cr13Mo6	200	240	—
25Cr13Mo6	230	As per agreement	—
40Cr13Mo10V2	230	As per agreement	—
40Cr7Al10Mo2	230	As per agreement	—
40Ni14	229	250 *Max*	—
35Ni5Cr2	229	250	—
30Ni13Cr2	250	As per agreement	—
40Ni16Cr4Mo2	241	250	—
40Ni16Cr4Mo3	241	As per agreement	—
31Ni10Cr3Mo6	269	As per agreement	—
40Ni10Cr3Mo6	269	As per agreement	-

NOTE — For improved machinability the microstructure of the steel may be mutually agreed to between the manufacturer and the purchaser.

Table 7 Povisional Limiting Rockwell Hardness for End Quench Test

(*Clause* 12.1)

Steel Grade	Limits of Spread	Hardness HRC at a Distance from End Quench Face in mm														
		1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
27C15	Maximum	55	54	51	48	42	39	37	33	31	29	28	27	27	26	
	Minimum	43	40	32	24	20	—	—	—	—	—	—	—	—	—	—
40Cr4	Maximum	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35
	Minimum	53	52	50	47	44	40	37	35	30	27	25	23	22	21	20
42Cr4Mo2	Maximum	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45
	Minimum	53	53	52	51	50	48	45	43	38	35	34	33	32	32	32
50Cr4Mo2	Maximum	65	65	64	64	63	63	62	61	60	58	56	55	54	53	53
	Minimum	57	56	56	55	53	52	50	48	44	41	40	39	38	37	37

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