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Draft Indian Standard

STRUCTURAL STEEL

PART 2 HOT ROLLED QUENCHED AND TEMPERED STEEL PLATES AND WIDE FLATS

[IS 2062 (Part 2)]

ICS 77.140.01

Wrought Steel Products Sectional Committee, MTD 04	Last date of comments : **12 March 2025**

FOREWORD

(*Formal clauses would be added later.*)

Quenching and tempering remain cornerstone techniques in modern steel production, delivering reliable and versatile solutions for industries that demand high-performance materials. Steels treated through this process provide a unique combination of strength, toughness, and durability, making them indispensable for challenging environments. Therefore, the Committee felt the need to formulate a standard on Quenched and tempered steel keeping in view its increasing use and demand in the Indian industries.

This new standard which will cover "Structural Steel - Hot rolled Quenched and tempered steel plates and wide flats" will serve as IS 2062 (Part 2). The IS 2062 (Part 1) will cover "Structural Steel - Hot rolled medium and high tensile non-alloy steel"

For all the tests specified in this standard (chemical/physical/others), the method as specified in relevant ISO Standard may also be followed as an alternate method.

While preparing the standard, assistance has been derived from the following international specifications:

International Standard	*Title*
ISO 630- 4 : 2021	Structural steels Part 4: Technical delivery conditions for high yield strength quenched and tempered structural steel plates and wide flats

The composition of the Committee responsible for the formulation of this standard is given in Annex B. (*to be added at later stage*)

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.

Draft Indian Standard

STRUCTURAL STEEL

PART 2 HOT ROLLED QUENCHED AND TEMPERED STEEL PLATES AND WIDE FLATS

1 SCOPE

1.1 This document specifies qualities for high-yield strength quenched and tempered structural steels. It applies to steel plates and wide flats rolled on reversing mills which are used in the quenched and tempered condition and normally intended for welded or bolted structures.

1.2 This document covers 10 grades and 5 qualities. Grades ISH S460Q, ISH S500Q, ISH S550Q, ISH S620Q, ISH S690Q, ISH S890Q and ISH S960Q are covered in **Tables 1, 3, 5** and **7**. Grades ISH SG460Q, ISH SG500Q, and ISH SG700Q are covered in **Table 2, 4, 6** and **8**. Not all grades are available in all qualities, and some qualities have Charpy V-notch requirements.

1.3 The steels specified in this document are applicable to hot-rolled flat products with a minimum nominal thickness of 3 mm and a maximum nominal thickness of 200 mm for grades ISH S460Q, ISH S500Q, ISH S550Q, ISH S620Q and ISH S690Q, a maximum nominal thickness of 125 mm for grades ISH S890Q and ISH S960Q, a maximum nominal thickness of 100mm for grades ISH SG460Q and ISH SG500Q and a maximum nominal thickness of 150 mm for grade ISH SG700Q.

2 REFERENCES

The standards listed in Annex A 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 agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 1956 and the following definitions shall apply.

3.1 Fine-Grain Steel — Steel with fine-grain structure with an equivalent index of grain size ≥ 6 determined in accordance with IS 4748/ ISO 643.

3.2 Quenching — Operation which consists of cooling a ferrous product more rapidly than in still air.

3.3 Tempering — Heat treatment applied to a ferrous product generally after quench hardening or other heat treatment to bring the properties to the required level.

NOTE — Tempering consists of heating to specific temperatures (< Ac1) and soaking one or more times followed by cooling at an appropriate rate.

4 SUPPLY OF MATERIALS

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

5 DESIGNATION (GRADES AND QUALITIES)

There shall be 10 grades of steel. Grades ISH S460Q, ISH S500Q, ISH S550Q, ISH S620Q, ISH S690Q, ISH S890Q and ISH S960Q are covered in **Tables 1, 3, 5, 7, 9, 10** and **12**. Grades ISH SG460Q, ISH SG500Q, and ISH SG700Q are covered in **Table 2, 4, 6, 8** and **11**. They differ in their minimum yield strength at room temperature.

Each grade is available in up to 5 qualities. These grades and qualities differ in their specified mechanical properties and impact energy requirements as mentioned below:

a) Quality A — Impact test not required;
b) Quality B — Impact testing at 0°C;
c) Quality C — Impact testing at –20°C;
d) Quality D — Impact testing at –40°C; and
e) Quality E — Impact testing at –60°C;

While placing the order, the steel should be designated by ‘Grade’ and ‘Quality’.

The requirements of **Tables 1, 3, 5, 7, 9, 10** and **12** or **Table 2, 4, 6, 8** and **11** are to be regarded separately. Each Table for **S** or **SG** grades is independent of the other without combining in any way.

5.1 Options

The following options may apply to products according to this document. If the purchaser does not indicate a wish to implement any of these options at the time of the order, the products shall be supplied in accordance with the basic specification.

5.1.1 Testing of tensile and impact properties at a frequency per each plate and wide flat as heat-treated.

5.1.2 On special request of the purchaser, the manufacturer shall inform the purchaser at the time of the order which of the alloying elements appropriate to the steel grade required will be deliberately added to the material to be delivered and reported in the heat analysis.

5.1.3 On special request of the purchaser, the manufacturer shall inform the purchaser at the time of the order which of the alloying elements appropriate to the steel grade required will be deliberately added to the material to be delivered and reported in the product analysis. The product

analysis shall be carried out at an agreed frequency when specified at the time of the order.

5.1.4 The steel making process shall be indicated (*see* **6.2**).

5.1.5 The product shall have a chemical composition required for hot-dip zinc-coating (*see* **10.3**).

5.1.6 Sheet, plate, strip and wide flats with a nominal thickness ≤ 16 mm shall be suitable for flanging without cracking (*see* **10.2.3**).

5.1.7 For flat products in nominal thickness ≥ 6 mm, except for hot rolled strip and plate cut from strip, the freedom from internal defects shall be verified in accordance with ISO 17577 (*see* **11**).

5.1.8 For each heat treatment unit, the impact properties only or the impact properties and the tensile properties shall be verified (*see* **9.5**).

5.1.9 Testing of impact properties in the transverse direction (*see* **9**).

5.1.10 For plates and wide flats, the permissible surface discontinuities and for the repair of surface defects by grinding and/or welding (*see* **13.3**).

5.1.11 Die stamping is not allowed or the position for die stamping shall be as indicated by the purchaser (*see* **18.1**).

6 MANUFACTURE

6.1 Steel shall be supplied in fully killed condition. The steels shall contain sufficient amount of nitrogen-binding elements and have a fine-grain structure.

6.2 The processes used in the steel making, casting and further hot rolling are left to the discretion of the manufacturer/supplier. If required, secondary refining in the form of ladle refining, vacuum degassing may follow steel making.

6.3 The products shall be supplied in the quenched and tempered condition.

NOTE — Direct quenching after hot-rolling followed by tempering is considered equivalent to conventional quenching and tempering.

7 CHEMICAL COMPOSITION

7.1 Ladle Analysis (Heat Analysis)

The ladle analysis or heat analysis of the steel, when carried out by the method specified in the relevant parts of IS 228 or any other established instrumental/chemical method, shall conform to the requirements as given in **Table 1** and **Table 2**. This analysis shall be made from a test sample, preferably taken during casting/teeming of the heat. In case of dispute, the procedure given in IS 228 and its relevant parts shall be the referee method and where test methods are not specified shall be as agreed to between the purchaser and the manufacturer/supplier. The ladle analysis shall

be reported in the test certificate.

7.1.1 The ladle analysis shall be determined once per cast.

Table 1 Chemical Composition of the Ladle Analysis for S Grades
(*Clauses* 5 *and* 7.1)

Designation		Ladle Analysis, Percent, *Max*														
Grade	Quality	C	Mn	S	P	Si	Cr	Ni	Mo	N	B	Cu	Nb (b,c)	Ti (b,c)	V (b,c)	Zr (b,c)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
All Grades	A to C	0.20	1.70	0.015	0.025	0.80	1.50	4.0	0.70	0.015	0.0050	0.50	0.06	0.05	0.12	0.15
	D, E			0.010	0.020											

b — There shall be at least 0.015 percent of a grain-refining element present. Aluminium is also one of these elements. The minimum content of 0.015 percent applies to soluble aluminium, this value is regarded as attained if the total aluminium content is at least 0.018 percent; in case of dispute, the soluble aluminium content shall be determined.

c — Nitrogen binding elements shall be in amounts sufficient to bind the nitrogen (for example min. 0.020 percent total aluminium). The usual guideline is a minimum aluminium to nitrogen ratio of 2:1, when no other nitrogen binding elements are present.

NOTES
1 Depending on the thickness of the product and the manufacturing conditions, the manufacturer may add to the steel one or several alloying elements up to the maximum values given in order to obtain the specified properties.

2 For killed steel, when the steel is killed by aluminium alone, the total aluminium content shall not be less than 0.020 percent. When the steel is killed by silicon alone, the silicon content shall not be less than 0.10 percent. When the steel is silicon-aluminium killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.010 percent.

Table 2 Chemical composition of the Ladle Analysis SG Grades
(*Clauses* 5 *and* 7.1)

Sl No.	Designation	Ladle Analysis, Percent, *Max*														
	Grade	Quality	C	Mn	S	P	Si	Cu	Ni	Cr	Mo	V	Nb	Ti	B	Zr
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
i)	ISH SG460Q	A, B, C	0.18	1.70	0.035	0.035	0.55	a	a	a	a	a	a	a	a	b
ii)	ISH SG500Q	A, B, C	0.22	2.00	0.040	0.035	0.55	a	a	a	0.05	0.11	0.05	a	a	b
iii)	ISH SG700Q	A, B, D	0.21	2.00	0.035	0.035	0.80	0.50	1.50	2.0	0.60	0.10	0.06	0.10	0.006	0.015

NOTES
a. There is no requirement, but the amount of these elements shall be determined for each heat and shall be reported in the inspection document. However, depending on the thickness of the product and the manufacturing conditions, the manufacturer may add to the steel one or several alloying elements to obtain the specified properties up to the maximum limits specified in Table A.1.

b. There is no requirement.

c. For killed steel, when the steel is killed by aluminium alone, the total aluminium content shall not be less than 0.020 percent. When the steel is killed by silicon alone, the silicon content shall not be less than 0.10 percent. When the steel is silicon-aluminium killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.010 percent.

7.2 Product Analysis

The product analysis shall be carried out when specified at the time of the order. The product analysis shall be carried out on the finished product from the standard position. The product analysis of grades ISH S460Q, ISH S500Q, ISH S550Q, ISH S620Q, ISH S690Q, ISH S890Q and ISH S960Q shall comply with the values given in **Table 3**.

The permitted deviations on analysis of grades ISH SG460Q, ISH SG500Q, and ISH SG700Q, relative to the values for heat analysis, are given in **Table 4**.

7.2.1 If a product analysis has been agreed upon at the time of enquiry and order, the purchaser shall specify the frequency if not once per cast.

Table 3 Chemical composition of the Product analysis based on Table 1
(*Clauses* 5 *and* 7.2)

Designation	Ladle Analysis, Percent, *Max*															
Grade	Quality	C	Mn	S	P	Si	Cr	Ni	Mo	N	B	Cu	Nb (b,c)	Ti (b,c)	V (b,c)	Zr (b,c)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
All Grades	A to C	0.22	1.80	0.017	0.030	0.86	1.60	4.1	0.74	0.016	0.0060	0.55	0.07	0.07	0.14	0.17
	D, E			0.012	0.025											

b — There shall be at least 0.010 percent of a grain-refining element present. Aluminium is also one of these elements. The minimum content of 0.010 percent applies to soluble aluminium, this value is regarded as attained if the total aluminium content is at least 0.013 percent; in case of dispute, the soluble aluminium content shall be determined.

c — Nitrogen binding elements shall be in amounts sufficient to bind the nitrogen (for example min. 0.015 percent total aluminium). The usual guideline is a minimum aluminium to nitrogen ratio of 2:1, when no other nitrogen binding elements are present.

NOTES
1 Depending on the thickness of the product and the manufacturing conditions, the manufacturer may add to the steel one or several alloying elements up to the maximum values given in order to obtain the specified properties.

Table 4 Permissible Variation for Product Analysis vs Ladle analysis of Table 2
(*Clauses* 5 *and* 7.2)

Sl No.	Element	Range of specified element, Percent	Permissible Variation over / under the Specified Limit, Percent, *Max*
(1)	(2)	(3)	(4)
i)	Carbon	≤ 0.015 >0.15 ≤ 0.22	0.03 0.04
ii)	Silicon	≤ 0.80	0.06
iii)	Manganese	≤ 2.00	0.10
iv)	Phosphorus	≤ 0.035	0.01
v)	Sulphur	≤ 0.04	0.01
vi)	Vanadium	≤ 0.10 >0.10 ≤ 0.25	0.01 0.02
vii)	Niobium	≤ 0.06	0.01
viii)	Boron	≤ 0.006	0.001
ix)	Titanium	≤ 0.10	0.01
x)	Copper	≤ 0.50	0.03

xi)	Nickel	≤ 1.00 > 1.00 ≤ 1.50	0.03 0.05
xii)	Chromium	≤ 0.90 > 0.90 ≤ 2.00	0.04 0.06
xiii)	Molybdenum	≤ 0.20 > 0.20 ≤ 0.40 > 0.40 ≤ 0.60	0.01 0.03 0.04
xiv)	Zirconium	≤ 0.15	0.03

7.3 Carbon Equivalent Value

The maximum carbon equivalent value (CEV) requirements for **Table 1** grades are given in **Table 5** and for **Table 2** grades are given in **Table 6**.

Carbon equivalent value (CEV) would be calculated based on ladle analysis only.

$$CEV = C + \frac{Mn}{6} + \frac{(Cr+Mo\quad)}{5} + \frac{(Ni+C\ )}{15}$$

Table 5 Maximum CEV based on the Ladle Analysis for Table 1
(*Clause* 7.3)

Sl No.	Designation Grade	Quality	Maximum CEV in Percentage for nominal product thickness in mm ≤ 50	> 50 ≤ 100	> 100 ≤ 125	> 125 ≤ 200
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	ISH S460Q	C, D, E	0.47	0.48	0.50	0.50
ii)	ISH S500Q	C, D, E	0.47	0.70	0.70	0.70
iii)	ISH S550Q	C, D, E	0.65	0.77	0.83	0.83
iv)	ISH S620Q	C, D, E	0.65	0.77	0.83	0.83
v)	ISH S690Q	C, D, E	0.65	0.77	0.83	0.83
vi)	ISH S890Q	C, D, E	0.72	0.82	0.83	—
vii)	ISH S960Q	C, D	0.82	0.85	0.85	—
NOTE — Max. CEV is increased for **5.1.1**, *see* 7.4						

Table 6 Maximum CEV[a] based on the Heat Analysis for Table 2
(*Clause* 7.3)

Sl No.	Designation		Maximum CEV in Percentage for nominal product thickness in mm	
	Grade	Quality	≤ 50	>50 ≤ 100
(1)	(2)	(3)	(4)	(5)
i)	ISH SG460Q	A, B, C	0.44	0.47
ii)	ISH SG500Q	A, B, C	0.47	0.50
iii)	ISH SG700Q	A, B, D	0.60	0.63
a — By agreement for ISH SG700Q NOTE — Max. CEV is increased for **5.1.1**, *see* 7.4				

7.4 When products are supplied with a control on Si, for example for hot-dip zinc-coating, so that there could be a need to increase the content of other elements like C and Mn to achieve the required tensile properties, the maximum carbon equivalent values of **Table 5** and **Table 6** shall be increased as follows:

a) For Si ≤ 0.04 percent, increase the value of the CEV by 0.02; and
b) For Si ≤ 0.25 percent, increase the value of the CEV by 0.01.

8 TENSILE TEST

The tensile properties at room temperature shall comply with the values specified in **Table 7** or **Table 8.**

8.1 Number of Tensile Tests

Number of test samples shall be 2 from each cast/heat and same form, grade, quality and delivery condition for thickness range as specified in **Table 7** and **Table 8** for the yield strength. On mutual agreement between the purchaser and the manufacturer, the test unit shall be taken on each plate and wide flat as heat treated for grades mentioned in **Table 8**.

8.2 Location of Samples and Orientation of Test Pieces

The samples shall be taken from any product of the test unit, from the location in the product as shown in Fig. 1. Additionally, for plates, sheet, wide strip and wide flats the samples shall be taken so that the axes of the test pieces are approximately midway between the edge and center line of the products.

For wide strip the sample shall be taken at an adequate distance from the end of the product. For narrow strip (< 600 mm wide) the sample shall be taken at an adequate distance from the end of the coil and at one third of the width.

Type of test	Nominal thickness of product	Direction of the longitudinal axis of the test piece in relation to the principal direction of rolling for product nominal widths of		Distance of the test piece from the rolled surface
		< 600	≥ 600	
Tensile [a]	≤ 30	longitudinal	transverse	≤ 30, 1, 1 rolled surface
	> 30			or, t, t/2, 1
Impact [b d]	> 12 [c]	longitudinal	longitudinal	≤ 2, > 12

a —In case of dispute, for products of nominal thickness greater than or equal to 3 mm use proportional test pieces of
gauge length $L_o = 5.65\sqrt{S_o}$ (*see* 8.3.1 and 8.3.2)
b — The axis of the notch shall be perpendicular to the surface of the product.
c — For nominal thicknesses t ≤ 12 mm (*see* 9.1)
d — For products nominal thickness t ≥ 40 mm impact test pieces shall be taken from ¼ t position.

FIG. 1 SAMPLE LOCATION

8.3 Tensile Test Pieces

The tensile strength, yield strength and percentage elongation of steel shall be determined from standard test pieces.

8.3.1 For flat products of nominal thickness > 30 mm a round test piece may be used with the longitudinal axis at 1/4 thickness, if a testing machine with an adequate capacity is not available. In cases of dispute, the total thickness of the plate shall be subdivided in equal thick flat test pieces. The average of the individual results of the mechanical tests shall be valid.

8.3.2 As a rule, test pieces with a proportional gauge length complying with the requirements $L_o = 5.65\sqrt{S_o}$ should be used for the tensile test, where L_o is the gauge length and S_o is the cross-

sectional area of the test piece.

8.3.3 Test pieces with a non-proportional gauge length, other than $5.65\sqrt{S_o}$ may be used in which case the elongation values shall be converted to $5.65\sqrt{S_o}$ in accordance with IS 3803 (Part 1).

8.4 Tensile Test

Yield strength, tensile strength and percentage elongation, when determined in accordance with IS 1608 (Part 1), shall conform to the requirements as given in **Table 7** and **Table 8**.

For the specified yield strength, the upper yield strength (R_{eH}) shall be determined. If a yield phenomenon is not present, the 0.2 percent proof strength (R_p 0.2) shall be determined.

8.4.1 Should a tensile test piece break outside the middle half of the gauge length [*see* IS 1608 (Part 1)] and the percentage elongation obtained is less than that specified, the test may be discarded at the manufacturer/supplier's option and another test made from the sample plate, strip, or flat.

8.5 The maximum stress-relief temperature should be at least 30°C below the tempering temperature and not be held for more than 1 hour. As this temperature is normally not known in advance it is recommended that the purchaser if he intends to perform a stress relief treatment to contact the steel producer. If the purchaser intends to stress relief the products at higher temperatures or for longer times than mentioned above the minimum values of the mechanical properties after such a treatment should be agreed upon at the time of the order.

Table 7 Tensile Properties at Room Temperature S Grades

(*Clause* 5 *and* 8.4)

Sl No.	Designation		Minimum Yield Strength R_{eH}, MPa [2] Nominal Thickness, mm				Tensile Strength R_m, MPa [2] Nominal Thickness, mm				Elongation A, Percentage *Min* at Gauge Length, $L_o = 5.65\sqrt{S_o}$
	Grade	Quality	≥3 ≤50	>50 ≤100	>100 ≤125	>125≤200	≥3≤50	>50≤100	>100≤125	>125≤200	≥3≤200
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
i)	ISH S460Q	C, D, E	460	440	400	400	550-720		500-670		17
ii)	ISH S500Q	C, D, E	500	480	440	440	590-770		540-720		17
iii)	ISH S550Q	C, D, E	550	530	490	490	640-820		590-770		16
iv)	ISH S620Q	C, D, E	620	580	560	560	700-890		650-830		15
v)	ISH S690Q	C, D, E	690	650	630	630	770-940	760-930	710-900		14
vi)	ISH S890Q	C, D, E	890	830	830	—	940-1100	880-1100	880-1100	—	11
vii)	ISH S960Q	C, D, E	960	850	850	—	980-1150	900-1100	900-1100	—	10

NOTES
1 For plates and wide flats with widths ≥600 mm, the direction transverse to the rolling direction applies.
2 1 MPa = 1N/mm^2 = 1MN/m^2 = 0.102 kgf/mm^2 = 144.4 psi.
3 If R_{eH} is not pronounced, refer to **8.4**

Table 8 Tensile Properties at Room Temperature SG Grades

(*Clause* 5 *and* 8.4)

Sl No.	Designation		Minimum Yield Strength R_{eH}, MPa [a] Nominal Thickness[c], mm				Tensile Strength R_m, MPa [a] Nominal Thickness, mm	Elongation[b] A, Percentage at Gauge Length, $L_o = 5.65\sqrt{S_o}$, *Min* Nominal Thickness(<150), mm		
	Grade	Quality	≤16	>16 ≤40	>40 ≤100	>100 ≤150	≤ 150	$L_o = 5.65\sqrt{S_o}$	Gauge length = 50 mm[d]	Gauge Length = 200 mm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	ISH SG460Q	A, B, C	460	450	420	e	570-720	15	20	15
ii)	ISH SG500Q	A, B, C	500	500	500	e	600-760	17	19	17
iii)	ISH SG700Q	A, B, D	690	690	620	620	760-930	14	16	14

a — 1 MPa = 1 N/mm2.
b — Only one of the three requirements is required. Unless specified in the order, the manufacturer may use either a proportional or

fixed gauge length specimen. When the test value is reported, the specimen used shall be reported.
c — The producer should be contacted for possible thickness limits.
d — If measured using a 40 mm wide tension test specimen, the elongation is determined in a 50 mm gauge length that includes the fracture and shows the greatest elongation.
e — Not available.

9 IMPACT TEST

The verification of the impact energy value shall be carried out, unless otherwise agreed upon. The impact properties of Charpy V-notch test pieces shall comply with the values specified in **Table 9** or **Table 11**. The orientation of the specimens shall be longitudinal, unless a transverse orientation is agreed between the purchaser and manufacturer (*see* **5.1.9** and the values mentioned in **Table 10**).

9.1 Preparation of Impact Test Pieces

V-notch test pieces shall be machined and prepared in accordance with IS 1757(Part 1)/ ISO 148-1. In addition, the following requirements apply for flat products:

a) For nominal thicknesses $12 < t < 40$ mm, standard 10 mm x 10 mm test pieces shall be machined in such a way that one side is not further away than 2 mm from a rolled surface, for nominal thicknesses ≥ 40 mm impact test pieces shall be taken from 1/4t position for plates;

b) For nominal thicknesses ≤ 12 mm, when test pieces with reduced widths are used, the largest width possible has to be chosen; If agreed upon at the time of enquiry and order, subsized test pieces shall be used in the case of nominal thicknesses of 6 mm ≤ t ≤ 12 mm. The largest possible standard sub-sized test piece (7.5 mm or 5.0 mm) shall be used; and

c) For nominal thickness < 6 mm no impact tests are required.

9.2 Impact Test

The impact test shall be carried out in accordance with IS 1757(Part 1)/ ISO 148-1 on V-notch specimen using 2 mm striker.

The average value of the three test results shall meet the specified requirement. One individual value may be below the minimum average value specified, provided that it is not less than 70 percent of that value.

Three additional test pieces shall be taken from the same sample in accordance with **9.3** and tested in any one of the following cases:

a) if the average of three impact values is lower than the minimum average value specified;

b) if the average value meets the specified requirement, but two individual values are lower than the minimum average value specified; and

c) if any one value is lower than 70 percent of the minimum average value specified.

The average value of the six tests shall be not less than the minimum average value specified. Not more than two of the individual values may be lower than the minimum average value specified and not more than one may be lower than 70 percent of this value.

9.3 The test sample shall be taken from the thickest product. One test sample shall be taken from thickest product per cast/heat. If the test sample taken from the thickest product rolled from a cast meets the requirements, the whole cast shall be deemed to meet the requirements of the test, if not, the test shall be performed on a product of next lower thickness rolled from same cast, if it meets the requirements specified, this particular thickness as also other sections of lower thickness shall be deemed to satisfy this specification. If this thickness also does not meet the requirements, the test shall be carried out on the next lower thickness and so on, because the toughness of the product will be dependent on the rolling direction as well as on the product size.

9.4 Impact test and their values at different temperatures other than specified in **Table 9**, **Table 10** and **Table 11** may be mutually agreed between the purchaser and the manufacturer/supplier. Accordingly, the impact test values may also be mutually agreed between the purchaser and the manufacturer/supplier.

9.5 If specified at the time of the order, on each heat treatment unit the impact properties only or the impact properties and the tensile properties shall be verified.

Table 9 Longitudinal Charpy V-notch properties [a] S Grades
(*Clauses* 5 *and* 9)

Sl No.	Designation		Minimum energy, J at test temperature [b], °C			
	Grade	Quality	0	-20	-40	-60
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	ISH S460Q	C	40	30	—	—
ii)	ISH S500Q					
iii)	ISH S550Q					
iv)	ISH S620Q					
v)	ISH S690Q					
vi)	ISH S890Q					
vii)	ISH S960Q					
viii)	ISH S460Q	D	50	40	30	—
ix)	ISH S500Q					
x)	ISH S550Q					
xi)	ISH S620Q					
xii)	ISH S690Q					
xiii)	ISH S890Q					
xiv)	ISH S960Q					
xv)	ISH S460Q	E	60	50	40	30
xvi)	ISH S500Q					
xvii)	ISH S550Q					

xviii)	ISH S620Q					
xix)	ISH S690Q					
xx)	ISH S890Q					
xxi)	ISH S960Q					

[a] For nominal thicknesses ≤12mm, where sub-sized test pieces are used (*see* 9.1), the minimum impact energy values given shall be reduced in proportion to the cross-sectional area of the test piece.
[b] Unless otherwise specified, the testing temperature for each quality is the lowest available with a specified energy level.

Table 10 Transverse Charpy V-notch properties [a,c] S Grades

(*Clauses* 5 *and* 9)

Sl No.	Designation		Minimum energy, J at test temperature [b], °C			
	Grade	Quality	0	-20	-40	-60
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	ISH S460Q	C	30	27	—	—
ii)	ISH S500Q					
iii)	ISH S550Q					
iv)	ISH S620Q					
v)	ISH S690Q					
vi)	ISH S890Q					
vii)	ISH S960Q					
viii)	ISH S460Q	D	35	30	27	—
ix)	ISH S500Q					
x)	ISH S550Q					
xi)	ISH S620Q					
xii)	ISH S690Q					
xiii)	ISH S890Q					
xiv)	ISH S960Q					
xv)	ISH S460Q	E	40	35	30	27
xvi)	ISH S500Q					
xvii)	ISH S550Q					
xviii)	ISH S620Q					
xix)	ISH S690Q					
xx)	ISH S890Q					
xxi)	ISH S960Q					

[a] For nominal thicknesses ≤12mm, where sub-sized test pieces are used (*see* 9.1), the minimum impact energy values given shall be reduced in proportion to the cross-sectional area of the test piece.
[b] Unless otherwise specified, the testing temperature for each quality is the lowest available with a specified energy level.
[c] *see* **5.1.9**

Table 11 Longitudinal Charpy V-notch properties [a] SG Grades

(*Clauses* 5 *and* 9)

Sl No.	Designation		Minimum impact energy, J, at test temperature, °C			Maximum thickness, mm
	Grade	Quality	0	-20	-40	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	ISH SG460Q	A	—	—	—	100
ii)		B	27	—	—	100
iii)		C	—	27	—	100
iv)	ISH SG500Q	A	—	—	—	100
v)		B	27	—	—	100
vi)		C	—	27	—	100
vii)	ISH SG700Q	A	—	—	—	150
viii)		B	—	27	—	150
ix)		C	—	—	27	150
a — For nominal thicknesses ≤12mm, where sub-sized test pieces are used (*see* 9.1), the minimum impact energy values given shall be reduced in proportion to the cross-sectional area of the test piece.						

10 TECHNOLOGICAL PROPERTIES

10.1 Weldability

The steels specified in this document do not have unlimited suitability for the various welding processes, since the behavior of a steel during and after welding depends not only on the material but also, on the dimensions and shape and on the manufacturing and service conditions of the components. General requirements for arc welding of the steels specified in this document shall be as given in IS 10842 (Part 2) or ISO 17642 (Part 2).

NOTE — With increasing product thickness and strength level cold cracking can occur. Cold cracking is caused by the following factors in combination:

a) the amount of diffusible hydrogen in the weld metal;
b) a brittle structure of the heat affected zone; and
c) significant tensile stress concentrations in the welded joint.

10.2 Formability and Flame Straightening

10.2.1 Hot-Forming

Hot forming is not recommended for quenched and tempered steels as the necessary heat treatment after hot forming is very difficult to reproduce.

10.2.2 Cold Formability

Cold forming leads to reduction in the ductility. Furthermore, it is important to draw the attention to the risk of brittle fracture in connection with hot-dip zinc coating.

10.2.3 Flangeability

If specified at the time of the order and mutually agreement between the purchaser and the manufacturer, plates and wide flats with a nominal thickness ≤ 16 mm are suitable for flanging without cracking with the indicative values for the inside minimum bend radii for cold forming as given in **Table 12**. (*see* **5.1.6,** for flangeability without cracking).

Table 12 Minimum Recommended Inside Bend Radii for Flanging S Grades
(*Informative for clause* 10.2.3)

Sl No.	Designation		Minimum recommended inside bend radii for nominal thicknesses (t) $3 \leq t \leq 16$ mm [a]	
	Grade	Quality	Axis of bend in transverse direction	Axis of bend in longitudinal direction
(1)	(2)	(3)	(4)	(5)
i)	ISH S460Q	C, D, E	3.0t	4.0t
ii)	ISH S500Q			
iii)	ISH S550Q			
iv)	ISH S620Q			
v)	ISH S690Q			
vi)	ISH S890Q	C, D, E	4.0t	5.0 t
vii)	ISH S960Q			
a The values are applicable for bend angles ≤ 90°.				

10.3 Hot-Dip Zinc-Coating

ISO 1461 should be used to specify coating requirements. ISO 14713-2 provides further guidance, including information on the influence of various factors, including steel chemical composition, on the coating formation.

Option mentioned in **5.1.5** can be used to order steels with a chemical composition required for hot-dip zinc coating. When **5.1.5** is implemented, the purchaser and manufacturer shall agree to a steel composition (heat analysis) of silicon and phosphorous according to either of the following:

a) Category A (or steels satisfying the requirements Si ≤ 0.03 % and Si+2.5P ≤ 0.09 %);
b) Category B (limited to 0.14 % ≤ Si ≤ 0.25 %);
c) Category D (limited to 0.25 % < Si ≤ 0.35 %).

NOTE — ISO 14713-2:2019, Table 1, gives guidance on typical coating characteristics associated with certain steel compositions on the basis of the surface composition of silicon and phosphorous.

The maximum carbon equivalent shall be increased by 0.02 or by 0.01 (*see* **7.4**).

NOTE — Products quenched in water can be susceptible to stress corrosion cracking after hot-dip zinc-coating.

In some cases, steels above S460 may be sensitive to cracking during galvanizing and therefore special care should be taken.

11 INTERNAL SOUNDNESS

Ultrasonic testing may be agreed upon at the time of the order. If specified at the time of the order, ultrasonic testing shall be carried out for flat products in nominal thicknesses ≥ 6 mm, except for hot rolled strip and plate cut from strip in accordance with ISO 17577 or with test methods and acceptance criteria agreed upon. (*see* **5.1.7**, Ultrasonic testing for flat products).

12 RE-TESTS

12.1 If a test does not give the specified results, two additional tests shall be carried out at random on the same lot. Both retests shall conform to the requirements of this standard; otherwise, the lot shall be rejected.
In the case of strip, retests on a rejected coil shall be carried out after the cutting of an additional longitudinal section of sufficient length to remove the coil end effect with a maximum of 20 m.

12.2 Re-Heat Treatment

If any heat-treated material fails to meet the mechanical requirements specified, the supplier may re-heat treat the material and, in that case, all mechanical properties shall be re-evaluated.

13 FREEDOM FROM DEFECTS

13.1 All finished steel shall be well and cleanly rolled to the dimensions, sections and masses specified. The finished material shall be reasonably free from surface flaws; laminations; rough/jagged and imperfect edges and all other harmful defects.

13.2 Minor surface defects may be removed by the manufacturer/supplier by grinding provided the thickness is not reduced locally by more than 4 percent below the minimum specified thickness. Reduction in thickness by grinding greater than 4 percent but not exceeding 7 percent may be made subject to mutual agreement between the purchaser and the manufacturer/supplier.

13.2.1 Subject to agreement with the purchaser, surface defects which cannot be dealt with as in 13.2 may be repaired by chipping or grinding followed by welding and inspection by a mutually agreed procedure such that,

a) After complete removal of the defects and before welding, the thickness of the item is in no place reduced by more than 20 percent;
b) Welding is carried out by approved procedure by competent operators with approved electrodes and that the welding is ground smooth to the correct nominal thickness; and
c) Subsequent to the finish grinding, the item maybe required to be normalized or otherwise heat-treated at the purchaser’s discretion.

13.3 Alternatively, the requirements for surface condition can be agreed at the time of enquiry and

order in accordance with ISO 7788 for plates and wide flats. (*see* **5.1.10**, surface condition).

14 DIMENSIONS

Unless otherwise agreed to between the purchaser and the manufacturer /supplier, the nominal dimensions of rolled products conforming to this standard shall be in accordance with the relevant Indian Standard.

15 TOLERANCES

Unless otherwise agreed to between the purchaser and the manufacturer/supplier, the rolling and cutting tolerances for steel products conforming to this standard shall be those specified in IS 1852.

16 CALCULATION OF MASS

The mass of the steel shall be calculated on the basis that steel weighs 7.85 g/cm^3.

17 DELIVERY

The products shall be supplied in the quenched and tempered condition (QT) as defined in clause **3** and **6.3**.

18 MARKING AND PACKING

18.1 The products shall be legibly marked using methods such as painting, stamping, laser marking, bar coding, durable adhesive labels or attached tags with the following:

a) The grade, the quality and if applicable the delivery condition indicated by its abridged designation;
b) Heat number or cast number; and
c) The manufacturer’s name or trademark.

The type of marking may be specified at the time of the order.

NOTES
1 Where the option for hot dip galvanizing is chosen (*see* **5.1.5**), the marking methods and materials used can be agreed upon in order to avoid interference with preparation for hot dip galvanizing (*see* ISO 14713-2).

2 In addition, if specified at the time of the order there shall be either no die stamping or only die stamping in positions indicated by the purchaser. [*see* **5.1.11** (Die stamping not allowed or at special position)].

18.2 Marking shall be at a position close to one end of each product or on the end cut face at the manufacturer's discretion.

18.3 Where products are supplied in securely tied bundles the marking shall be on a label attached to the bundle or on the top product of the bundle.

18.4 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 products may be marked with the Standard Mark.

ANNEX A
(*Clause* 2)
LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 228 (in various parts)	Methods of chemical analysis of steels
IS 1599 : 2023/ ISO 7438 : 2020	Metallic materials — Bend test (*fifth revision*)
IS 1608(Part 1) : 2022/ ISO 6892-1 : 2019	Metallic materials — Tensile testing — Part 1 Method of test at room temperature (*fifth revision*)
IS 1730 : 1989	Steel plates, sheets, strips and flats for structural and general engineering purposes — Dimensions (*second revision*)
IS 1757(Part 1): 2020/ ISO 148-1 : 2016	Metallic materials — Charpy pendulum impact test : Part 1 Test method (*fourth revision*)
IS 1852 : 1985	Specification for rolling and cutting tolerances for hot rolled steel Products (*fourth revision*)
IS 1956 (in various parts)	Glossary of terms relating to iron and steel (*second revision*)
IS 3803 (Part 1) : 2023/ ISO 2566-1 : 2021	Steel — Conversion of elongation values: Part 1 Carbon and low alloy steels (*third revision*)
IS 4748 : 2021/ ISO 643:2019	Steel — Micrographic determination of the apparent grain size (*third revision*)
IS 8910 : 2022/ ISO 404 : 2013	General technical delivery requirements for steel and steel products (*second revision*)
IS 9595 : 1996	Metal arc welding of carbon and carbon manganese steels — Recommendations (*first revision*)
IS 10842 (Part 2) : 2019/ ISO 17642-2 : 2005	Destructive tests on welds in metallic materials — Cold cracking tests for weldments — Arc welding processes - part 2 self-Restraint Tests (*first revision*)
ISO 1461 : 2022	Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods
ISO 14713-2 : 2019	Zinc coatings — Guidelines and recommendations for the protection against corrosion of iron and steel in structures — Part 2: Hot dip galvanizing
ISO 17577: 2016	Steel — Ultrasonic testing of steel flat products of thickness equal to or greater than 6 mm