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IS 2041 (2009): Steel Plates for Pressure Vessels Used at Moderate and Low Temperature [MTD 4: Wrought Steel Products]



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लिए इस्पात प्लेटें — विशिष्टि
(तीसरा पुनरीक्षण)

Indian Standard
**STEEL PLATES FOR PRESSURE VESSELS USED AT
MODERATE AND LOW TEMPERATURE —
SPECIFICATION**
(*Third Revision*)

ICS 23.040.10; 77.140.75

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wrought Steel Products Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1962 and subsequently revised in 1982 and 1995. 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 practices being followed by the Indian industry and overseas standards of steel plates for pressure vessels used at moderate and low temperature.

In this revision following modifications have been made:

- a) Amendment No. 1 has been incorporated.
- b) Clause on scope, references, grades, manufacture, heat treatment, orientation, tolerances, re-test and marking have been modified.
- c) Table 1, Table 2 and Table 3 have been modified.
- d) Clause on terminology has been incorporated.
- e) Requirement of Normalizing Rolling has been added.
- f) Grades have been increased to 8, covering requirements of popular International grades.
- g) Tolerances have been modified with respect to ISO 7452 : 2002 'Hot-rolled structural steel plates — Tolerances on dimensions and shape'.

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.

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

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.

Indian Standard

STEEL PLATES FOR PRESSURE VESSELS USED AT MODERATE AND LOW TEMPERATURE — SPECIFICATION

(*Third Revision*)

1 SCOPE

This standard covers the requirements of steel plates for fabrication of fusion welded pressure vessels for moderate and low temperature services with room temperature and elevated temperature properties.

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

<i>IS No.</i>	<i>Title</i>
228	Methods for chemical analysis of steel
1599 : 1985	Method for bend test (<i>second revision</i>)
1608 : 2005	Metallic materials — Tensile testing at ambient temperature (<i>third revision</i>)
1757 : 1988	Method for Charpy impact test (V-notch) for metallic materials (<i>second revision</i>)
1956	Glossary of terms relating to iron and steel
3803 (Part 1) : 1989	Steel-conversion of elongation values: Part 1 Carbon and low alloy steels (<i>second revision</i>)
8910 : 1978	General technical delivery requirements for steel and steel products
11630 : 1986	Method for ultrasonic testing of steel plates for pressure vessels and special applications (<i>first revision</i>)
IS/ISO 7452 : 2002	Hot-rolled structural steel plates — Tolerances on dimensions and shape

3 TERMINOLOGY

For the purpose of this standard, the following definitions in addition to those given in the relevant parts of IS 1956 shall apply.

3.1 Micro-Alloying Elements — Elements, such as niobium, boron, vanadium and titanium added singly or in combination to obtain higher strength to weight ratio combined with better toughness, formability and weldability as compared to unalloyed steel of similar strength level.

3.2 Normalizing Rolling — A hot rolling process in which the final rolling passes are carried out at a suitable higher temperature, following by cooling in natural air to a temperature below the transformation temperature, in order to produce a structure, analogous to that obtained by a separate normalizing treatment of hot rolled product. However, the specified values of the mechanical properties shall be met even after the subsequent normalizing.

4 GENERAL REQUIREMENTS

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

4.2 Order shall include the following information, as applicable:

- a) Quantity (weight or number of pieces of plates);
- b) Dimensions of plates;
- c) Grade designation;
- d) Heat treatment conditions;
- e) Impact test requirements, if any;
- f) Inspection and testing conditions, if any; and
- g) Additional requirements, if any.

5 GRADES

The steel grades covered by this standard are given in following two qualities:

- a) The room temperature quality in Grades R220, R260, R275, R355.
- b) The elevated temperature quality in Grades H235, H265, H295, H355.

6 MANUFACTURE

6.1 Steel shall be manufactured by any process of steel making at the discretion of the manufacturer. Steel may be further treated in secondary refining process.

6.2 The steel shall be of killed quality and made to fine austenitic grain size practice where Al (total) content on ladle analysis shall be 0.02 percent (minimum).

6.3 When rolled from continuously cast slabs, ratio of slab to plate thickness shall be minimum 2.5 to 1.

7 CHEMICAL COMPOSITION

7.1 The ladle analysis of the material, when carried out by the method specified in the relevant parts of IS 228 or other established instrumental/chemical method shall be as given in Table 1. In case of dispute the procedure given in relevant part of IS 228 shall be the referee method. However, where the method is not given in IS 228 or its relevant parts, the referee method shall be as agreed to between the purchaser and the manufacturer.

7.2 Product Analysis

Permissible variation in the case of product analysis from the limits specified in 7.1 shall be as given in Table 2.

8 HEAT-TREATMENT

8.1 Unless specified otherwise, plates above 12 mm thickness shall be supplied in normalized condition.

8.2 Subject to agreement between the purchaser and the manufacturer, normalizing process may be replaced with normalizing rolling.

9 FREEDOM FROM DEFECTS

9.1 The finished plates shall be reasonably free from harmful defects, such as cracks, seams, laminations, rough and jagged edges, etc.

9.2 Superficial defects may be removed by grinding or by other suitable means, provided the material is not reduced below the permissible limits of tolerance at the dressed spot. Hammer dressing, patching by welding, etc, shall not be permitted.

9.3 Edge Imperfection

9.3.1 Line discontinuities 25 mm and less in length on the edges of a plate are acceptable.

Table 1 Chemical Composition

(Clause 7.1)

Grade	C Max	Si	Mn	P Max	S Max	Al (Total) Min	N Max	Nb Max	V Max	Ti Max	Nb+V+ Ti Max	Cr Max	Cu Max	Mo Max	Ni Max
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
R220	0.21	0.15-0.35	0.60-1.50	0.035	0.035	0.020	0.012	—	—	—	—	—	—	—	—
R260	0.25	0.15-0.35	0.85-1.50	0.035	0.035	0.020	0.012	—	—	—	—	—	—	—	—
R275	0.16	0.40, Max	0.80-1.50	0.025	0.015	0.020	0.012	0.05	0.05	0.03	0.05	0.30	0.30	0.08	0.50
R355	0.18	0.50, Max	1.10-1.70	0.025	0.015	0.020	0.012	0.05	0.10	0.03	0.12	0.30	0.30	0.08	0.50
H235	0.16	0.35, Max	0.60-1.20	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30
H265	0.20	0.40, Max	0.80-1.40	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30
H295	0.20	0.40, Max	0.90-1.50	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30
H355	0.22	0.60, Max	1.10-1.70	0.025	0.015	0.020	0.012	0.02	0.02	0.03	0.06	0.30	0.30	0.08	0.30

NOTES

- For Grades R220, R 260, R275, R355 Carbon content over the maximum specified shall be increased by 0.03 percent for plates over 12 mm thickness.
- Microalloying elements Nb and V may be added to Grades R220 & R260, subject to mutual agreement between purchaser and manufacturer/supplier.
- For product thicknesses < 6 mm, a minimum Mn of 0.6 percent is permitted.
- The minimum Al (total) content may not be applicable, if Nb, Ti or V either singly or in combination are additionally used for Nitrogen binding.
- If only Al is used for nitrogen binding, a ratio Al/N \geq 2 shall apply.
- Cr+Cu+Mo shall not exceed 0.45 percent.
- Elements not listed in the table shall not be intentionally added to the steel without agreement of the purchaser.
- Closer limits of composition may be agreed to between the supplier and the purchaser.
- Whenever micro alloying elements are added for achieving the strength, maximum carbon equivalent shall not exceed 0.50 for steels used for welding.
- Carbon equivalent (CE) based on ladle analysis = $C + Mn/6 + (Cr+Mo+V)/5 + (Ni+Cu)/15$.

Table 2 Permissible Variation in Product Analysis
(Clause 7.2)

Sl No.	Constituent	Variation Over the Specified Maximum or Under the Minimum Limit, Percent
(1)	(2)	(3)
i)	Carbon	
	Up to and including 0.23 percent	0.02
	Over 0.23 percent	0.03
ii)	Silicon	0.02
iii)	Manganese	0.05
iv)	Phosphorus	0.005
v)	Sulphur	0.005
vi)	Niobium	0.01
vii)	Vanadium	0.02
viii)	Titanium	0.01
ix)	Chromium	0.05
x)	Copper	0.05
xi)	Molybdenum	0.03
xii)	Nickel	0.05

9.3.2 Edge imperfections beyond the limit of 9.3.1 may be ground to the acceptable limit provided plate size remains within respective tolerance.

10 DIMENSIONS AND TOLERANCES

10.1 Unless otherwise agreed the dimensional tolerances for hot-rolled steel sheet shall be as given in IS/ISO 7452.

10.2 Unless otherwise agreed the restricted thickness tolerances shall be as given in IS/ISO 7452.

11 THEORETICAL MASS

A density of 7.85 g/cm³ shall be taken for the determination of the theoretical mass of plate.

12 MECHANICAL PROPERTIES

12.1 Tensile Test

12.1.1 Number of Tests

One tensile test shall be taken from each plate as rolled. When plates are produced from coils, three tensile tests shall be made from each coil.

12.1.2 Orientation of Test Sample

The longitudinal axis of the tensile test sample shall be perpendicular to the final rolling direction of the plate.

12.1.3 Location of Test Sample

The tensile test sample shall be taken at a distance of one-fourth of the total width of plate from one longitudinal edge of the plate. In the case of plates produced from coils, the sample shall be taken from head end, middle and tail end of the coil.

12.1.4 When heat-treatment is specified, the test sample shall be taken from the plate in the heat treated condition or from full thickness test samples simultaneously heat treated with the plate.

12.1.5 Test sample shall be prepared in accordance with IS 1608.

12.1.6 Tensile Test Result

12.1.6.1 The tensile test shall be carried out in accordance with IS 1608, generally using a proportional gauge length $L_0 = 5.65 \sqrt{S_0}$ where S_0 is the cross-sectional area of the test piece. Test pieces with a non-proportional gauge length may be used; in this case the elongation values shall be converted in accordance with IS 3803 (Part 1). The tensile strength, yield stress and percentage elongation shall be as given in Table 3.

12.1.6.2 In case of plates from coil, all material between any two test locations that meet the requirement is acceptable.

12.1.6.3 Should a tensile test piece break out side the middle half of its gauge length and if the percentage elongation is less than the specified minimum, the test may be discarded at the suppliers option and a fresh test conducted from the same plate.

12.1.6.4 Elevated temperature tensile test shall be carried out for 'H' quality grades at 300°C and the minimum yield stress values shall be as indicated in Table 3. Other temperatures and values can also be mutually agreed to. One test sample shall be taken from each thickness product per cast/heat.

12.2 Bend Test

12.2.1 Bend test shall be conducted, if agreed to at the time of ordering.

12.2.2 One bend test sample shall be taken from each plate as rolled or from each coil. Orientation and location shall be same as for tensile tests.

12.2.3 Bend test shall be carried out in accordance with IS 1599. The test piece, shall withstand, without fracture or cracking being bend over 180° against mandrel of diameter three times the thickness of test sample.

12.3 Low Temperature Charpy Impact Test (V-notch Tests)

12.3.1 Charpy impact test shall be conducted, if agreed to at time of ordering for the Grades R220 and R260.

12.3.2 Number of Tests

One impact test (3 samples) shall be made from each plate as rolled. When plates are supplied from coils, the number of impact test required shall be the same as the number for tensile test.

Table 3 Mechanical Properties
(Clauses 12.1.6.4 and 12.3.5)

Grade	Yield Stress MPa, <i>Min</i>				Tensile Strength MPa	Elongation Percent on Gauge Length $5.65\sqrt{S_0}$, <i>Min</i>	Impact Energy (J) Minimum at a Temperature				0.2 percent Proof Stress at 300°C MPa
	≤ 16	> 16 to 40 mm	> 40 to 60 mm	> 60 to 100 mm			+20	0	-20	-40	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
R220	220	220	220	220	415-540	21	50	40	27	20	—
R260	260	260	260	260	490-620	21	50	40	27	20	—
R275	275	265	255	235	390-510	23	80	70	50	40	—
R355	355	345	335	315	490-640	21	80	70	50	40	—
H235	235	225	215	200	360-480	24	40	34	27	—	153
H265	265	255	245	215	410-530	22	40	34	27	—	173
H295	295	290	285	260	460-580	21	40	34	27	—	192
H355	355	345	335	315	510-650	20	40	34	27	—	232

NOTES

1 Impact test shall be at any one temperature as mutually agreed.

2 Impact test is optional for Grades R220 and R260.

3 The orientation of Impact test specimen shall be longitudinal to the rolling direction for R220, R260, R275, R355 grades and transverse to the rolling direction for H235, H265, H295 and H355 grades.

4 Stringent impact test temperature and values can be mutually agreed.

5 For thickness > 100 mm, Yield stress to be mutually agreed.

12.3.3 Orientation

The orientation of impact test specimen shall be longitudinal to the rolling direction for 'R' quality grades and transverse to the rolling direction for H quality grades. Notch axis shall be perpendicular to the rolled surface.

12.3.4 When heat-treatment is specified the test sample shall be taken from the plate in heat treated condition or from full thickness test samples simultaneously heat treated with the plate.

12.3.5 The average impact test values of three test samples lying next to one another in the test sample, when tested in accordance with IS 1757, and the temperature of impact test shall be as per Table 3. Any individual value may be below the specified minimum but shall not be less than 75 percent of that value.

12.3.5.1 Any other stringent test temperature and impact values can be agreed to at the time of ordering.

12.4 Re-test

12.4.1 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.

12.5 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 NON-DESTRUCTIVE TEST

Ultrasonic testing of plates as per IS 11630 may be carried out as per mutual agreement at the time of ordering. The acceptance standard shall be specified by the purchaser.

14 RUST PROTECTION

After inspection and approval, if so desired by the purchaser, each plate shall be coated with one coat of boiler linseed oil or a suitable rust preventive material, as agreed to between the supplier and the purchaser.

15 MARKING

15.1 For plates 6 mm and over in thickness, the name or trade-mark of the manufacturer, cast number, grade and plate number shall be legibly steel dye stamped/stencil marking on each finished plate at 150 mm from one of the transverse edges at the middle.

15.2 For plates under 6 mm in thickness, the marking

specified in 15.1 shall be legibly stenciled instead of stamping.

15.3 BIS Certification Marking

The material may also be marked with the Standard Mark.

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

ANNEX A

(Foreword)

COMMITTEE COMPOSITION

Wrought Steel Products Sectional Committee, MTD 4

<i>Organization</i>	<i>Representative(s)</i>
Tata Steel Ltd, Jamshedpur	DR D. BHATTACHARJEE (Chairman) SHRI INDRANIL CHAKRABORTY (<i>Alternate I</i>) DR A. N. BHAGAT (<i>Alternate II</i>)
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DGS& D, Bhilai Nagar/Delhi	REPRESENTATIVE
Escorts Knowledge Management Centre, Faridabad	SHRI ALOK NAYAR
Essar Steels Ltd, Hazira	DR A. K. DAS SHRI R. K. BALASUBRAMANIAM (<i>Alternate</i>)
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Ministry of Steel (Government of India), New Delhi	SHRI A. C. R. DAS SHRI B. D. GHOSH (<i>Alternate</i>)
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Rashtriya Ispat Nigam Ltd (VSP), Vishakhapatnam	SHRI P. K. SEN SHRI P. SRINIVAS (<i>Alternate</i>)
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<i>Organization</i>	<i>Representative(s)</i>
SAIL, Bokaro Steel Plant, Bokaro	DR M. M. S. SODHI SHRI P. S. REDDY (<i>Alternate</i>)
SAIL, Central Marketing Organization, Kolkata	SHRI P. C. JHA SHRI B. V. S. PANDIT (<i>Alternate</i>)
SAIL, Durgapur Steel Plant, Durgapur	SHRI A. KANAN
SAIL, IISCO Steel Plant, Burnpur	SHRI A. K. SINGH
SAIL, Research & Development Centre for Iron & Steel, Ranchi	DR RAMEN DATTA DR B. K. JHA (<i>Alternate</i>)
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Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

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Amendments Issued Since Publication

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