INTERNATIONAL STANDARD 4996

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Hot-rolled steel sheet of high yield stress structural quality

Tôles laminées à chaud en acier de construction à haute limite d'élasticité

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Price based on 10 pages

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4996 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in July 1976.

It has been approved by the member bodies of the following countries :

Australia	India	South Africa, Rep. of
Belgium	Iran	Spain
Bulgaria	Italy	Sweden
Canada	Korea, Rep. of	Switzerland
Czechoslovakia	Mexico	Turkey
Denmark	Netherlands	United Kingdom
Egypt, Arab Rep. of	New Zealand	U.S.A.
Finland	Poland	U.S.S.R.
France	Portugal	Yugoslavia
Germany	Romania	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Hungary
Norway

Printed in Switzerland

Hot-rolled steel sheet of high yield stress structural quality

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard applies to hot-rolled steel sheet of high yield stress structural quality in the grades and classes listed in tables 1 and 2, with the use of microalloying elements. The product is intended for structural purposes where particular mechanical properties are required. It is generally used in the delivered condition and is intended for bolted, riveted or welded structures.

Because of the combination of higher strength and micro-alloy composition, it is possible to obtain savings in mass along with better formability and weldability as compared with steel sheet without microalloying elements. The product is produced on a wide strip mill, not a plate mill.

1.2 This product is commonly produced in the range of thicknesses of 1,6 to 6 mm inclusive and widths of 600 mm and over, in coils and cut lengths.

1.3 Hot-rolled sheet less than 600 mm wide may be slit from wide sheet and will be considered as sheet.

NOTE — Hot-rolled sheet up to but not including 3 mm in thickness is commonly known as "sheet". Hot-rolled sheet 3 mm and over in thickness is commonly known as either "sheet" or "plate".

1.4 This International Standard does not cover steels intended for boilers or pressure vessels, or steels designated as commercial quality or drawing qualities (covered in ISO 3573), or steels to be rerolled to cold-reduced products (covered in ISO 3576), or steels designated as weathering steels, having increased atmospheric corrosion resistance, or steels having improved formability properties compared with those included in this document.

NOTE — Approximate conversions into inches are given in the annex for information only.

2 REFERENCES

ISO 82, *Steel — Tensile testing.*

ISO/R 85, *Bend test for steel.*

ISO 86, *Steel — Tensile testing of sheet and strip less than* 3 mm *and not less than* 0,5 mm *thick.*

ISO/R 87, *Simple bend testing of steel sheet and strip less than* 3 mm *thick.*

3 DEFINITIONS AND OTHER INFORMATION

3.1 microalloying elements : Elements, such as niobium, vanadium, titanium, etc., added singly or in combination to obtain higher strength levels combined with better formability, weldability, and toughness as compared to non-alloyed steel produced to equivalent strength levels.

3.2 hot-rolled steel sheet : A product obtained by rolling heated steel through a continuous-type or reversing-type wide strip mill to the required sheet thickness. The product has a surface covered with oxide or scale resulting from the hot rolling operation.

3.3 hot-rolled descaled steel sheet : Hot-rolled steel sheet from which oxide or scale has been removed, commonly by pickling in an acid solution. Descaling may also be performed by mechanical means such as grit blasting. Some change in properties may result from descaling.

As a deterrent to rusting, a coating of oil is usually applied to hot-rolled descaled steel sheet, but sheet may be furnished not oiled if required. The oil is not intended as a forming lubricant and shall be easily removable with degreasing chemicals. On request, the manufacturer shall advise the purchaser which type of oil has been used.

3.4 mill edge : A normal side edge produced in hot rolling. Mill edges may contain some irregularities such as cracked or torn edges or thin (feathered) edges.

3.5 edge trimmed : A normal edge obtained by shearing, slitting or trimming a mill edge product.

3.6 Surface condition

Oxide or scale on hot-rolled steel sheet is subject to variations in thickness, adherence and colour. Removal of the oxide or scale by pickling or blast cleaning may disclose surface imperfections not readily visible prior to this operation.

4 CONDITIONS OF MANUFACTURE

4.1 Steelmaking

Unless otherwise agreed by the interested parties, the processes used in making the steel and in manufacturing hot-rolled sheet are left to the discretion of the manufacturer. On request, the purchaser shall be informed of the steelmaking process being used.

4.2 Chemical composition

The chemical composition (cast analysis) shall not exceed the values given in table 1.

4.3 Chemical analysis

4.3.1 *Cast analysis*

A cast analysis of each cast of steel shall be made by the manufacturer to determine the percentage of carbon, manganese, phosphorus and sulphur. On request, this analysis shall be reported to the purchaser or his representative.

4.3.2 *Verification analysis*

A verification analysis may be made by the purchaser to verify the specified analysis of the semi-finished or finished steel and shall take into consideration any normal heterogeneity. The sampling method and deviation limits shall be agreed upon between manufacturer and purchaser at the time of ordering.

4.4 Weldability

This product is normally suitable for welding if appropriate welding conditions are selected. For undescaled steel it may be necessary to remove the scale or oxide depending upon the welding method. As the carbon content increases above 0,15 %, spot welding becomes increasingly difficult.

TABLE 1 – Chemical composition (cast analysis), %

Grade	Class	Method of deoxidation	C max.	Mn max.	Si max.	P max.	S max.
HS355	C	NE	0,20	1,60	0,50	0,040	0,040
	D	CS	0,20	1,60	0,50	0,035	0,035
HS390	C	NE	0,20	1,60	0,50	0,040	0,040
	D	CS	0,20	1,60	0,50	0,035	0,035
HS420	C	NE	0,20	1,70	0,50	0,040	0,040
	D	CS	0,20	1,70	0,50	0,035	0,035
HS460	C	NE	0,20	1,70	0,50	0,040	0,040
	D	CS	0,20	1,70	0,50	0,035	0,035
HS490	C	NE	0,22	1,70	0,50	0,040	0,040
	D	CS	0,22	1,70	0,50	0,035	0,035

NOTES

1 NE = Non-rimming
CS = Special killed

2 The nitrogen content is controlled; normally it should not exceed 0,009 % for NE steel or 0,015 % for CS steel.

3 Each grade includes at least one microalloying element such as vanadium, titanium, niobium, etc.

4 Class C steels are to be used in cases where, owing to conditions and the general design of the structure, some resistance to brittle fracture is necessary.

Class D steels are to be used in cases where, owing to loading conditions and the general design of the structure, a high resistance to brittle fracture is necessary.

4.5 Application

It is desirable that hot-rolled steel sheet be identified for fabrication by the name of the part or by the intended application, which shall be compatible with the grade and class specified.

4.6 Mechanical properties

At the time that the steel is made available for shipment, the mechanical properties shall be as stated in table 2 when they are determined on test pieces obtained in accordance with the requirements of clause 7.

5 DIMENSIONAL TOLERANCES

Dimensional tolerances applicable to hot-rolled steel sheet of high yield stress structural quality shall be as given in tables 3 to 10 inclusive.

6 SAMPLING

6.1 Tensile test

One representative sample for the tensile test required in table 2 shall be taken from each lot of sheet for shipment. A lot consists of 50 tonnes or less of sheet of the same grade and class rolled to the same thickness and condition.

6.2 Bend test (when specified)

One representative sample for the bend test shall be taken from each lot of sheet for shipment. A lot consists of all sheet of the same grade and class rolled to the same thickness and condition.

TABLE 2 – **Mechanical properties**[1)]

Grade	R_e min.[2)] N/mm²		R_m min. (information only) N/mm²	A min. %[3)]				180°[4)] bend mandrel diameter
				$e < 3$		$3 \leqslant e \leqslant 6$		
	R_{eH}	R_{eL}		$L_o = 50$ mm	$L_o = 80$ mm	$L_o = 5{,}65\sqrt{S_o}$	$L_o = 50$ mm	
HS355	355	335	430	18	16	22	21	2a
HS390	390	370	460	16	14	20	19	2a
HS420	420	400	490	14	12	19	18	3a
HS460	460	440	530	12	10	17	16	3a
HS490	490	470	570	10	8	15	14	4a

1) R_{eH} = upper yield stress
R_{eL} = lower yield stress
R_m = tensile strength
A = percentage elongation after fracture
L_o = gauge length on test piece
S_o = original cross-sectional area of gauge length
a = thickness of bend test piece
e = thickness of steel sheet, in millimetres
1 N/mm² = 1 MPa

2) Either R_{eH} or R_{eL} shall be measured and either value shall meet the minimum requirement. The yield stress values can be measured by 0,5 % elongation proof stress (proof stress under load) or by 0,2 % offset when a definite yield phenomenon is not present.

3) For thicknesses up to 3 mm use either $L_o = 50$ mm or $L_o = 80$ mm. For thicknesses 3 mm inclusive to 6 mm inclusive use either $L_o = 5{,}65\sqrt{S_o}$ or $L_o = 50$ mm. In case of dispute, however, only the results obtained on a proportional test piece will be valid for material 3 mm and over in thickness.

4) The bend test is performed only when specified (see 7.2). The bend mandrel diameters in table 2 are for test pieces prepared for laboratory testing. Conditions during fabrication may be more severe and not simulate those during laboratory testing.

7 MECHANICAL PROPERTY TESTS

7.1 Tensile test

The tensile test shall be carried out in accordance with ISO 82 and ISO 86. Transverse test pieces shall be taken midway between the centre and edge of the sheet as rolled.

7.2 Bend test (when specified)

The transverse bend test piece shall withstand being bent through 180°, in the direction as shown in figure 1, around an inside diameter as shown in table 2, without cracking on the outside of the bent portion. The bend test shall be carried out at ambient temperature and as specified in ISO/R 85 and ISO/R 87.

Small cracks on the edges of test pieces and cracks which require magnification to be visible shall be disregarded.

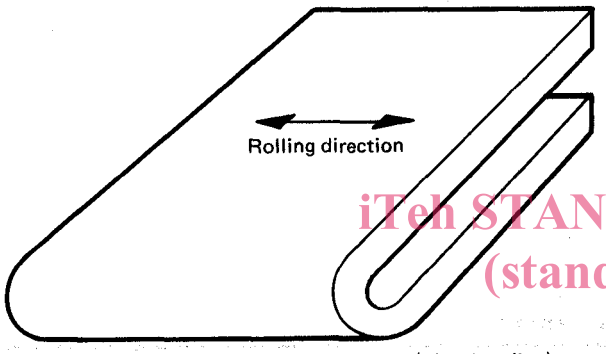

FIGURE 1 — **Transverse bend test piece** (after bending)

8 RETESTS

8.1 Machining and flaws

If any test piece shows defective machining or develops flaws, it shall be discarded and another test piece substituted.

8.2 Elongation

If the percentage elongation of any test piece is less than that specified in table 2 and if any part of the fracture is outside the middle half of the gauge length as scribed before the test, the test shall be discarded and a retest shall be carried out.

8.3 Additional tests

If a test does not give the specified results, two more tests shall be carried out at random on the same lot. Both retests shall conform to the requirements of this International Standard; otherwise, the lot may be rejected.

9 RESUBMISSION

9.1 The manufacturer may resubmit for acceptance the products that have been rejected during earlier inspection because of unsatisfactory properties, after he has subjected them to a suitable treatment (selection, heat treatment) which, on request, will be indicated to the purchaser.

In this case, the tests shall be carried out as if they applied to a new batch.

9.2 The manufacturer has the right to present the rejected products to a new examination for compliance with the requirements for another grade or class.

10 WORKMANSHIP

The surface condition shall be that normally obtained in a hot-rolled or hot-rolled descaled product.

The steel sheet in cut lengths shall be free from amounts of laminations, surface flaws and other imperfections that are detrimental to subsequent appropriate processing.

Processing for shipment in coils does not afford the manufacturer the opportunity to observe readily or to remove defective portions as can be carried out on the cut length product.

11 INSPECTION AND ACCEPTANCE

11.1 While not usually required for products covered by this International Standard, when the purchaser specifies that inspection and tests for acceptance be observed prior to shipment from the manufacturer's works, the manufacturer shall afford the purchaser's inspector all reasonable facilities to determine that the steel is being furnished in accordance with this International Standard.

11.2 Steel that is reported to be defective after arrival at the user's works shall be set aside, properly and correctly identified and adequately protected. The manufacturer shall be notified in order that he may properly investigate.

12 COIL SIZE

When hot-rolled steel sheet is ordered in coils, a minimum or range of acceptable inside diameters (I.D.) shall be specified. In addition, the maximum outside diameter (O.D.) and the maximum acceptable coil mass shall be specified.

13 MARKING

Unless otherwise stated, the following minimum requirements for identifying the steel shall be legibly stencilled on the top of each lift or shown on a tag attached to each coil or shipping unit :

a) the manufacturer's name or identifying brand;

b) the number of this International Standard;

c) the grade and class designations;

d) the order number;

e) the product dimensions;

f) the lot number;

g) the mass.

14 INFORMATION TO BE SUPPLIED BY THE PURCHASER

To specify adequately requirements under this International Standard, inquiries and orders shall include the following information :

a) the number of this International Standard;

b) the name, quality, grade and class of the material (for example, hot-rolled steel sheet, high yield stress structural quality, grade HS355 class C);

c) the dimensions of the product and the quantity required;

d) the application (name of part) if possible (see 4.5);

e) whether pickling or descaling by grit or shot blasting is required (material so specified will be oiled unless ordered not oiled) (see 3.3);

f) the type of edge (see 3.4 and 3.5);

g) whether cropped ends are required;

h) the report of the mechanical properties and/or the cast analysis, if required (see 4.6 and 4.3.1);

i) limitations on masses and dimensions of individual coils and bundles, if applicable (see clause 12);

j) inspection and tests for acceptance prior to shipment from the manufacturer's works, if required (see 11.1).

NOTE – A typical ordering description is as follows :

International Standard 4996 hot-rolled steel sheet, high yield stress structural quality, grade HS355, class D, 3 × 1 200 × 2 440 mm, 40 000 kg, for part No. 5432, bumper bracket, edge trimmed, furnish report of mechanical properties, maximum lift 4 000 kg.

TABLE 3 – **Thickness tolerances for coils[1] and cut lengths, in grades HS355, HS390 and HS420 (including descaled material)**

(For grades HS460 and HS490 increase the thickness tolerances by 25 % applying normal rounding-off procedures)

Values in millimetres

Specified widths	Thickness tolerances[2], over and under, for specified thicknesses				
	1,6 up to and including 2,0	over 2,0 up to and including 2,5	over 2,5 up to and including 3,0	over 3,0 up to and including 4,0	over 4,0 up to and including 6,0
600 up to and including 1 200	0,23	0,25	0,26	0,29	0,34
Over 1 200 up to and including 1 500	0,25	0,28	0,29	0,31	0,35
over 1 500 up to and including 1 800	0,28	0,30	0,31	0,33	0,36
Over 1 800	–	0,33	0,34	0,35	0,38

1) The values specified do not apply to the uncropped ends for a length l of a mill edge coil.

Length l would be calculated using the follliwng formula :

$$\text{Length } l \text{ in metres} = \frac{90}{\text{Thickness in millimetres}}$$

provided that the result was not greater than 30 m.

2) Thickness is measured at any point on the sheet not less than 40 mm from a side edge.

TABLE 4 – **Width tolerances for coils and cut lengths (including descaled material), mill edge**

Values in millimetres

Specified widths	Tolerance[1)]
Up to and including 1 200	+ 30 0
Over 1 200 up to and including 1 500	+ 35 0
Over 1 500 up to and including 1 800	+ 40 0
Over 1 800	+ 50 0

1) The values specified do not apply to the uncropped ends for a length l of a mill edge coil.

Length l would be calculated using the following formula :

$$\text{Length } l \text{ in metres} = \frac{90}{\text{Thickness in millimetres}}$$

provided that the result was not greater than 30 m.

TABLE 5 – **Width tolerances for coils and cut lengths (including descaled material), edge trimmed, not resquared**

Values in millimetres

Specified widths	Tolerance
Up to and including 1 200	+ 6 0
Over 1 200 up to and including 1 500	+ 8 0
Over 1 500	+ 10 0

TABLE 6 – **Length tolerances for cut lengths (including descaled material), not resquared**

Values in millimetres

Specified lengths	Tolerance
Up to and including 3 000	+ 20 0
Over 3 000 up to and including 6 000	+ 30 0
Over 6 000	+ 0,5 % × length 0

TABLE 7 – **Camber tolerances for coils and cut lengths (including descaled material), not resquared**

Form	Camber tolerance
Coils	25 mm in any 5 000 mm length
Cut lengths	0,5 % × length

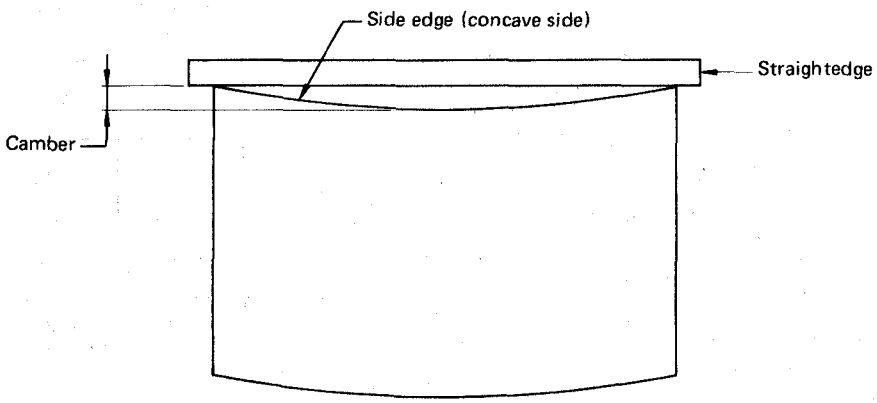

FIGURE 2 – **Measurement of camber**

Camber is the greatest deviation of a side edge from a straight line, the measurement being taken on the concave side with a straightedge.

TABLE 8 — **Out-of-square tolerances for cut lengths (including descaled material), not resquared**

Dimensions	Out-of-square tolerance
All thicknesses and all sizes	1 % X width

TABLE 9 — **Out-of-square[1] tolerances for resquared[2] material (including descaled material)**

Values in millimetres

Specified lengths	Specified widths	Out-of-square tolerance
		Up to and including 6 mm thickness
Up to and including 3 000	Up to and including 1 200	$+\frac{2}{0}$
	Over 1 200	$+\frac{3}{0}$
Over 3 000	All widths	$+\frac{3}{0}$

1) See figure 3.

2) When measuring material to resquared tolerances, consideration may have to be given to extreme variations in temperature.

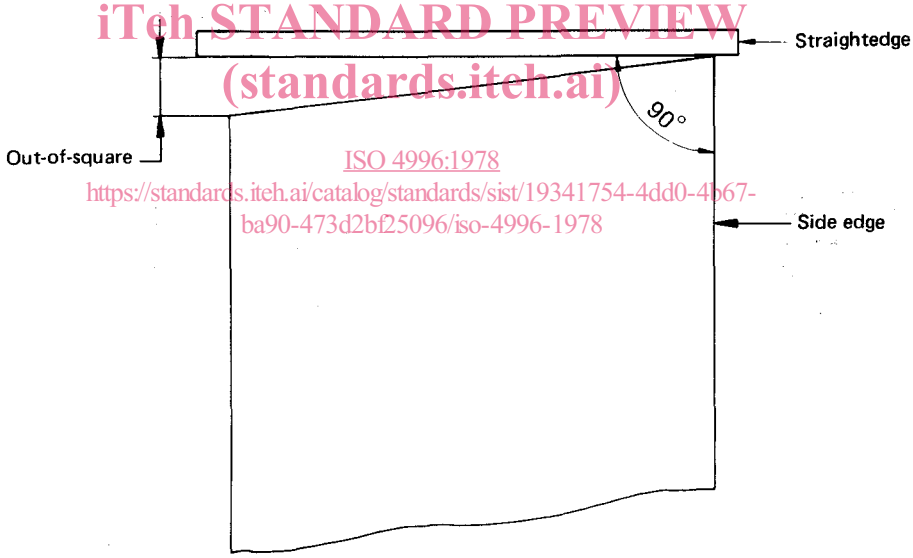

FIGURE 3 — **Measurement of out-of-square**

Out-of-square is the greatest deviation of an end edge from a straight line at right angles to a side and touching one corner, the measurement being taken as shown in figure 3. It can also be measured as one-half the difference between the diagonals of the cut length sheet.