INTERNATIONAL STANDARD

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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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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established 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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4996 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 12, *Continuous mill flat rolled products*.

This fourth edition cancels and replaces the third edition (ISO 4996:1999), which has been technically revised.

Hot-rolled steel sheet of high yield stress structural quality

1 Scope

1.1 This International Standard applies to hot-rolled steel sheet of high yield stress structural quality 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 structures that may include bolting, riveting and welding.

Because of the combination of higher strength and microalloy 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 thicknesses from 1,6 mm to 6 mm 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 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 steel intended for boilers or pressure vessels, steels designated as commercial quality or drawing quality (ISO 3573), steels to be rerolled to cold-reducing products, steels designated as weathering steels, having increased atmospheric corrosion resistance, or steels having improved formability properties compared with those in this International Standard.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*

ISO 16160, *Continuously hot-rolled steel sheet products — Dimensional and shape tolerances*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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 compared to non-alloyed steel produced to equivalent strength levels

3.2
hot-rolled steel sheet
product obtained by rolling heated steel through a continuous-type or reversing-type wide strip-mill to the required sheet thickness, the product having 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

NOTE Descaling may also be performed by a mechanical means such as grit blasting. Some changes in properties may result from descaling.

3.4 Edges

3.4.1
mill edge
normal edge without any definite contour produced in hot rolling

NOTE Mill edges may contain some irregularities such as cracked or torn edges or thin (feathered) edges.

3.4.2
sheared edge
normal edge obtained by shearing, slitting or trimming a mill edge product

NOTE Normal processing does not necessarily provide a definite positioning of the slitting burr.

3.5
aluminum killed
steel which has been deoxidized with aluminum sufficient to prevent the evolution of gas during solidification

4 Conditions of manufacture

4.1 Steelmaking

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 (heat analysis) shall not exceed the values given in Tables 1 and 2.

4.3 Chemical analysis

4.3.1 Heat analysis

An analysis of each heat of steel shall be made by the manufacturer to determine compliance with the requirements given in Tables 1 and 2. When requested, the heat analysis shall be reported to the purchaser or the purchaser's representative.

Each of the elements listed in Table 2 shall be included in the report of the heat analysis. When the amount of copper, nickel, chromium or molybdenum present is less that 0,02 %, the analysis may be reported at "< 0,02 %".

Table 1 — Chemical composition (heat analysis), %

Grade	Class [a]	Method of deoxidation [b]	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	0,20	1,70	0,50	0,040	0,040
	D	CS	0,20	1,70	0,50	0,035	0,035
The nitrogen content is controlled: normally it should not exceed 0,009 % for NE steel or 0,015 % for CS steel.							
Each grade contains one or more microalloying elements with the following restrictions: Ti – 0,10 % max., Nb – 0,08 % max., V – 0,10 % max.. The amounts of these elements are subject to agreement between the manufacturer and purchaser. In the absence of an agreement, the amounts shall be at the discretion of the manufacturer. In all cases, the sum of Ti, Nb, and V shall be less than or equal to 0,22 %. In no case shall Nb, V or Ti be less than 0,005 %.							
[a] Class C steels are to be used in cases where, owing to the 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.							
[b] NE = non-rimming; CS = aluminum killed.							

Table 2 — Limits on additional chemical elements

Contents in percent

Elements	Heat analysis max.	Product analysis max.
Cu [a]	0,20	0,23
Ni [a]	0,20	0,23
Cr [a, b]	0,15	0,19
Mo [a, b]	0,06	0,07
[a] The sum of copper, nickel, chromium, and molybdenum shall not exceed 0,50 % on heat analysis. When one or more of these elements is specified, the sum does not apply; in which case, only the individual limits on the remaining elements will apply.		
[b] The sum of chromium and molybdenum shall not exceed 0,16 % on heat analysis. When one or more of these elements are specified, the sum does not apply; in which case, only the individual limits on the remaining elements will apply.		

4.3.2 Product analysis

A product 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. Non-killed steels (such as rimmed or capped steels) are not technologically suited to product analysis.

For killed steels, the sampling method shall be agreed between the manufacturer and purchaser at the time of ordering. The product analysis tolerances shall be in accordance with Table 3.

Table 3 — Product analysis tolerances

Element	Range of specified element %	Tolerance over maximum specified percent
Carbon	⩽ 0,15	0,03
	> 0,15 ⩽ 0,40	0,04
Manganese	⩽ 0,60	0,03
	> 0,60 ⩽ 1,15	0,04
	> 1,15 ⩽ 1,70	0,05
Phosphorus	⩽ 0,04	0,010
Sulfur	⩽ 0,04	0,010
Silicon	⩽ 0,30	0,03
	> 0,30 ⩽ 0,50	0,04
Nitrogen	⩽ 0,030	0,005
NOTE The above maximum tolerance is the allowable excess over the specified requirement and not the heat analysis.		

4.4 Weldability

The product is 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.

4.5 Application

It is desirable that the specified product 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. Proper identification of the part may include visual examination, prints or description, or a combination of these.

4.6 Mechanical properties

At the time that the steel is made available for shipment, the mechanical properties shall be as stated in Table 4, if they are determined on test pieces obtained in accordance with the requirements of Clause 7.

4.7 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.

4.8 Oiling

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 drawing or forming lubricant and should be easily removable with degreasing chemicals. On request, the manufacturer shall advise the purchaser which type of oil has been used. The product may be ordered unoiled.

Table 4 — Mechanical properties

Grade	R_e min. [a] N/mm^2	R_m min. (for information only) N/mm^2	A min., % [b]			
			$e < 3$		$3 \leqslant e \leqslant 6$	
			L_o = 50 mm	L_o = 80 mm	$L_o = 5{,}65\sqrt{S_o}$	L_o = 50 mm
HS355	355	430	18	16	22	21
HS390	390	460	16	14	20	19
HS420	420	490	14	12	19	18
HS460	460	530	12	10	17	16
HS490	490	570	10	8	15	14

R_e = yield stress – may be either R_{eL} or R_{eH}, but not both

R_{eH} = upper yield stress

R_{eL} = lower yield stress

R_m = tensile strength

A = percentage elongation after fracture

L_o = initial gauge length on test piece

S_o = original cross-sectional area of gauge length

e = thickness of steel sheet, in millimetres

1N/mm^2 = 1 MPa

[a] 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.

[b] For thicknesses up to 3 mm, use either L_o = 50 mm or L_o = 80 mm. For thicknesses from 3 mm to 6 mm, 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.

5 Dimensional tolerances

Dimensional tolerances applicable to hot-rolled steel sheet shall be as given in ISO 16160.

Restricted thickness tolerances are given in ISO 16160.

6 Tensile test sampling

One representative sample for the tensile test required in Table 4 shall be taken from each lot of sheet for shipment. A lot consists of 50 t or less of sheet of the same designation, rolled to the same thickness and condition.

7 Tensile test

The tensile test shall be carried out in accordance with ISO 6892. Transverse test pieces shall be taken midway between the centre and edge of the sheet as rolled.