
**Hot-rolled steel sheet in coils of
higher yield strength with improved
formability and heavy thickness for
cold forming**

*Tôles fortes en acier laminées à chaud à limite d'élasticité et aptitude
au formage accrues, en bobines, pour formage à froid*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

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

This third edition cancels and replaces the second edition (ISO 20805:2011), which has been technically revised.

Hot-rolled steel sheet in coils of higher yield strength with improved formability and heavy thickness for cold forming

1 Scope

This document is applicable to continuous hot-rolled steel sheet in coils of higher yield strength with improved formability and heavy thickness for cold forming. The steel can be treated to achieve inclusion control. It is generally used in the as-delivered condition.

As a result of the combination of higher strength and improved formability, it is possible to obtain savings in mass along with better weldability.

The product is intended for applications where parts are to be fabricated requiring better formability than is provided by normal high-yield-strength steel sheet.

The steel sheet is produced in a number of grade designations designed to be compatible with differing application requirements.

This document does not apply to

- steels intended for boilers or pressure vessels,
- steels designated as commercial quality, drawing quality or structural quality,
- steels rolled to cold-reduced products,
- steels designated as weathering steels, having increased atmospheric corrosion resistance, or
- those products rolled on a plate mill.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

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 with non-alloyed steel produced to equivalent strength levels

3.2

hot-rolled steel sheet in coils

steel sheet in coil form manufactured through hot-rolling process, where the material was heated before rolling to achieve the required sheet thickness and tolerances

Note 1 to entry: The product has a surface covered with oxide or scale resulting from the hot-rolling operation.

3.3

hot-rolled descaled steel sheet in coils

hot-rolled steel sheet in coils (3.2), from the surface of which oxide or scale has been removed, commonly by pickling in an acid solution

Note 1 to entry: This product is normally supplied oiled.

Note 2 to entry: Descaling may also be performed by mechanical methods such as grit blasting.

3.4

mill edge

normal edge without any definite contour produced in hot-rolling

Note 1 to entry: Mill edges may contain some irregularities such as cracked or torn edges or thin (feathered) edges.

3.5

sheared edge

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

Note 1 to entry: Normal processing does not necessarily provide a definite positioning of the slitting burr.

3.6

lot

up to a specified quantity of steel sheet of the same grade rolled to the same thickness and condition

3.7

edge camber

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

4 Dimensions

The product is commonly produced in the range of thicknesses greater than 6 mm to 25 mm, and widths of 600 mm and over, in coils. Hot-rolled sheet less than 600 mm wide can be slit from wide sheet and will be considered as sheet.

5 Conditions of manufacture

5.1 Steelmaking

Unless otherwise agreed upon 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.

5.2 Chemical composition

5.2.1 The chemical composition (heat analysis) shall conform to the requirements in [Tables 1](#) and [2](#).

5.2.2 The steel covered by this document shall contain microalloying elements. The chemical composition may be agreed between the interested parties at the time of enquiry and ordering.

Table 1 — Chemical analysis (heat analysis)

Mass fractions in percent

All grades	C	Mn	P	S
	0,15 max.	1,65 max.	0,025 max.	0,030 max.
As the form of sulfide inclusions may have a certain influence on the cold-forming properties of the products, the manufacturers may, at their discretion, influence the form of inclusions by adding certain elements, such as Ce or Ca, or may choose a very low sulfur content for these steels.				
These steels shall also contain one or more of the following elements: V, Ti or Nb. When used singly or in combination, these elements shall be present at a minimum level of 0,005 %. Other alloying elements may be present, but are not required.				

Table 2 — Limits on additional chemical elements

Mass fractions in percent

Cu, ^a max.	Heat analysis	0,20
	Product analysis	0,23
Ni, ^a max.	Heat analysis	0,20
	Product analysis	0,23
Cr, ^{a,b} max.	Heat analysis	0,15
	Product analysis	0,19
Mo, ^{a,b} max.	Heat analysis	0,06
	Product analysis	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 are specified, the sum does not apply, in which case, only the individual limits on the remaining elements 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 apply.		

5.3 Chemical analysis

5.3.1 Heat analysis

An analysis of each sheet shall be made by the manufacturer in order to determine compliance with the requirements given in [Tables 1](#) and [2](#). On request, a report of the heat analysis shall be made available to the purchaser or the purchaser's representative. Each of the elements listed in [Tables 1](#) and [2](#) shall be included in the report of the heat analysis. When the amount of copper, nickel, chromium or molybdenum present is less than 0,02 % the analysis may be reported as "< 0,02 %".

5.3.2 Product analysis

A product analysis may be made by the purchaser in order to verify the specified analysis of the product. The product analysis tolerance and limits on additional chemical elements shall be in accordance with [Tables 2](#) and [3](#).

5.4 Mechanical properties

At the time that the steel is made available for shipment, the mechanical properties shall be as given in [Table 4](#), when they are determined on test pieces in accordance with the requirements of [Clause 7](#). Any additional property requirements specified or required are subject to agreement between the interested parties at the time of enquiry and ordering.

Table 3 — Product analysis tolerances from Table 1

Mass fraction in percent

Element	Maximum or range of specified element	Tolerance over maximum specified
C	≤ 0,15	0,03
Mn	> 1,15 to ≤ 1,65	0,05
P	≤ 0,025	0,010
S	≤ 0,030	0,010

NOTE The above maximum tolerance is the allowable excess over the requirement of heat analysis shown in Table 1. For example, for all grades in this document, the following product analysis values are within these tolerances: C 0,18 %, Mn 1,70 %, P 0,035 %, S 0,040 %.

Table 4 — Mechanical properties

Grade	R_e	R_m	A^b min. %			
	min. ^a	min.	$L_o = 5,65 \sqrt{S_o}$	$L_o = 50$ mm for sheet thickness		
	MPa ^c	MPa ^c		6 mm < t ≤ 12 mm	12 mm < t ≤ 19 mm	19 mm < t ≤ 25 mm
325	325	410	19	21	24	26
355	355	420	18	20	23	25
420	420	480	15	17	19	21
490	490	540	12	13	16	17
560	560	610	9	10	12	13

R_e = yield strength can be either R_{eL} or R_{eH} not both

R_{eH} = upper yield strength

R_{eL} = lower yield strength

R_m = tensile strength

A = percentage elongation after fracture

L_o = gauge length of original test piece

S_o = original cross-sectional area of gauge length, in square millimetres

t = thickness of steel sheet in mm

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

^b In case of dispute, only the results obtained on a 50 mm test piece will be valid.

^c 1 MPa = 1 N/mm²

5.5 Application

It is desirable that hot-rolled steel sheet be identified for fabrication by the name of the part or by the intended application. Proper identification of the part may include visual examination, prints or description, or a combination of these.

5.6 Weldability

The product is normally suitable for welding if appropriate welding conditions are selected. For non-descaled steel, it may be necessary to remove the scale or oxide depending upon the welding method.

5.7 Surface condition

The designation AR describes the as-rolled 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. The steel shall be supplied as-rolled (3.2) or descaled (3.3) and oiled, as requested by the purchaser at the time of enquiry and ordering. If neither condition is specified, the delivery will be as-rolled.

5.8 Oiling

The designation DO describes the descaled and oiled condition. As a deterrent to rusting, a coating of oil is usually applied to hot-rolled descaled steel sheet. The oil is not intended as a drawing or forming lubricant and shall be easily removable with degreasing chemicals. On request, the manufacturer shall advise the purchaser of the type of oil that has been used. Hot-rolled descaled steel sheet may be ordered not oiled, if required, in which case the supplier has limited responsibility if oxidation occurs.

6 Dimensional and shape tolerances

6.1 Dimensional and shape tolerances applicable to hot-rolled steel sheet in coils of structural quality and heavy thickness shall be in accordance with Tables 5 and 6. These tolerances also apply to descaled material.

6.2 Edge camber shall not exceed 25 mm in any 5 000 mm of length (see Figure 1).

Table 5 — Thickness tolerances for heavy thickness hot-rolled sheet (including descaled) in coils

Dimensions and tolerances in millimetres

Specified widths	Thickness tolerances for specified thicknesses ^a				
	6,00 < t ≤ 8,00	8,00 < t ≤ 10,00	10,00 < t ≤ 12,50	12,50 < t ≤ 16,00	16,00 < t ≤ 25,00
≥ 600 w 1 200	±0,29	±0,32	±0,35	±0,38	±0,40
> 1 200 w 1 500	±0,30	±0,33	±0,36	±0,39	±0,42
> 1 500 w 1 800	±0,31	±0,34	±0,37	±0,40	±0,44
w 1 800	±0,35	±0,40	±0,43	±0,48	±0,50

w = width

The values specified do not apply to the uncropped ends for a length, *l*, of a mill-edge coil. The length, *l*, would be calculated using the following formula:

$$\text{Length, } l, \text{ in metres} = \frac{90}{\text{Thickness in millimetres}} \quad \text{provided that the result was not greater than 20 m inclusive of both ends.}$$

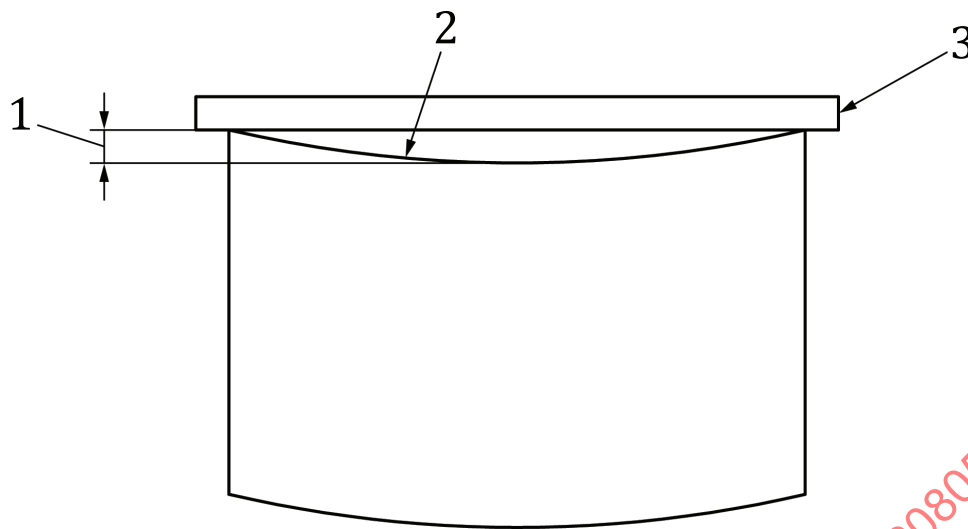
^a Thickness is measured at any point on the sheet not less than 40 mm from a side edge for mill-edge material and not less than 25 mm from the edge for sheared material.

Table 6 — Width tolerances for heavy-thickness hot-rolled sheet in coils

Dimensions and tolerances in millimetres

Specified widths	Mill edges		Sheared edges	
≥ 600 w 1 200	+28	−0	+5	−0
> 1 200 w 1 500	+38	−0	+6	−0
> 1 500 w 1 800	+45	−0	+8	−0
w 1 800	+50	−0	+10	−0

w = width



Key

- 1 edge camber
- 2 side edge (concave side)
- 3 straight edge

Figure 1 — Measurement of edge camber

7 Sampling — Tensile test

One representative sample for the tensile test required in [Table 4](#) shall be taken from each lot 50 t or less of sheet for shipment.

8 Mechanical property tests

8.1 Tensile test

The tensile test shall be carried out in accordance with ISO 6892-1. Transverse test pieces shall be taken mid-way between the centre and edge of the sheet as-rolled.

8.2 Impact test

While not usually specified, if so agreed at the time of ordering, impact tests may be specified for material ordered according to this document. The test piece shall be taken in the longitudinal direction and the test shall be carried out in accordance with ISO 148-1. Material less than 11 mm in thickness will result in sub-size impact tests.

9 Retests

9.1 Machining and flaws

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

9.2 Elongation

If the percentage of elongation of any test piece is less than that specified in [Table 4](#) 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.

9.3 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 document; otherwise, the lot shall be rejected.

10 Resubmission

10.1 The manufacturer may resubmit for acceptance the products that have been rejected during earlier inspection because of unsatisfactory properties, after the rejected products have been subjected to a suitable treatment (e.g. 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.

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

11 Workmanship

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

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

11.3 Processing for shipment in coils does not afford the manufacturer the opportunity to observe readily or to remove imperfect portions, as can be carried out on the cut-length product. However, this does not relieve the manufacturer of the responsibility to provide a product that meets the requirement for surface condition that is normally obtained in a hot-rolled or hot-rolled descaled product.

12 Inspection and acceptance

12.1 While not usually required for products covered by this document, 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 document.

12.2 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 they may properly investigate.

13 Coil size

When hot-rolled steel sheet in accordance with this document is ordered in coils, a minimum inside diameter (ID) or range of acceptable inside diameters shall be specified. In addition, the maximum outside diameter (OD) and the maximum acceptable coil mass shall be specified.