INTERNATIONAL STANDARD

ISO 20805

Third edition
2017-11

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

Reference number
ISO 20805:2017(E)

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Foreword

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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 min.[a] MPa[c]	R_m min. MPa[c]	A[b] min. % $L_o = 5{,}65\sqrt{S_o}$	L_o = 50 mm for sheet thickness 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/mm^2.

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]				
	$6{,}00 < t \leq 8{,}00$	$8{,}00 < t \leq 10{,}00$	$10{,}00 < t \leq 12{,}50$	$12{,}50 < t \leq 16{,}00$	$16{,}00 < t \leq 25{,}00$
≥ 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:

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