

**BS ISO 13976:2016**



**BSI Standards Publication**

# **Hot-rolled steel sheet in coils of structural quality and heavy thickness**

**National foreword**

This British Standard is the UK implementation of ISO 13976:2016. It supersedes BS ISO 13976:2005 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/109, Coated and Uncoated Flat Products to be Used for Cold Forming.

A list of organizations represented on this committee can be obtained on request to its secretary.

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**Hot-rolled steel sheet in coils of  
structural quality and heavy thickness**

*Tôles fortes en acier de construction laminées à chaud en bobines*



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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. [www.iso.org/directives](http://www.iso.org/directives)

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The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 12, *Continuous mill flat rolled products*.

This third edition cancels and replaces the second edition (ISO 13976:2005), which has been technically revised.

# Hot-rolled steel sheet in coils of structural quality and heavy thickness

## 1 Scope

This document applies to hot-rolled carbon/manganese steel sheet in coils of structural quality without the use of microalloying elements. It is generally used in the delivered condition and is intended for bolted, riveted or welded structures. The product is produced on a wide sheet mill.

The product is intended for structural purposes where particular mechanical properties are required.

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

This document does not cover steels intended for boilers or pressure vessels, or steels designated as commercial quality or drawing qualities, or steels rolled to cold-reduced products, or 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 <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://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 from the surface of which oxide or scale has been removed, commonly by pickling in an acid solution

Note 1 to entry: Descaling can also be performed by mechanical means such as grit blasting. Some increase in hardness and some loss of ductility can result from descaling.

Note 2 to entry: This product is normally supplied oiled.

### 3.4 **mill edge**

normal edge produced without any definite contour produced in hot-rolling

Note 1 to entry: Mill edges can contain some irregularities such as cracked or torn edges on 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**

50 t or less of steel sheet of the same grade rolled to the same thickness and condition

### 3.7 **edge camber**

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

## 4 Dimensions

Hot-rolled steel sheet in coils of structural quality and heavy thickness is produced in the range of thicknesses greater than 6 mm to 25 mm, and widths of 600 mm and over, in coils.

## 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

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



**Table 1 — Chemical composition (heat analysis)**

Mass fractions in percent

Grade	C max.	Mn max.	P max.	S max.	Si max.	N max.
HR185	0,16	1,5	0,030	0,035	0,40	0,015
HR235	0,18	1,5	0,030	0,035	0,40	0,015
HR275	0,18	1,5	0,030	0,035	0,40	0,015
HR295	0,21	1,5	0,030	0,035	0,55	0,015
HR325	0,18	1,6	0,030	0,035	0,55	0,015
HR355	0,22	1,5	0,030	0,035	0,55	0,015

**Table 2 — Limits on additional chemical elements**

Mass fractions in percent

Element	Cu <sup>a</sup> max.	Ni <sup>a</sup> max.	Cr <sup>ab</sup> max.	Mo <sup>ab</sup> max.	Nb max.	V <sup>c</sup> max.	Ti max.
Heat analysis	0,20	0,20	0,15	0,06	0,008	0,008 <sup>c</sup>	0,008
Product analysis	0,23	0,23	0,19	0,07	0,018	0,018	0,018

<sup>a</sup> The sum of copper, nickel, chromium and molybdenum shall not exceed 0,50 % on the 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.

<sup>b</sup> The sum of chromium and molybdenum shall not exceed 0,16 % 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.

<sup>c</sup> Where residual V levels greater than 0,008 % occur due to high levels of V in natural ores, such material may be supplied after agreement between the manufacturer and purchaser.

## 5.3 Chemical analysis

### 5.3.1 Heat analysis

An analysis of each heat 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 and shall take into consideration any normal heterogeneity. The product analysis tolerances shall be in accordance with [Tables 2](#) and [3](#).

**Table 3 — Product analysis tolerances**

Mass fractions in percent

Element	Maximum or range of specified element	Tolerance over maximum specified
C	> 0,15 to ≤ 0,22	0,04
Mn	> 1,15 to ≤ 1,6	0,05
P	≤ 0,030	0,010
S	≤ 0,035	0,010
Si	> 0,40 to ≤ 0,55	0,05
N	≤ 0,015	0,005

NOTE The above maximum tolerance is the allowable excess over the specified requirement and not the heat analysis. For example: for Grade HR295, the following product analysis values are within these tolerances: C 0,25 %, Mn 1,55 %, P 0,040 %, S 0,045 %, Si 0,60 %, N 0,020 %.

## 5.4 Mechanical properties

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

## 5.5 Application

It is desirable that the specified product 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

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

NOTE When the mass fraction of carbon exceeds 0,15 %, spot welding becomes increasingly difficult.

## 5.7 Surface condition

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.

## 5.8 Oiling

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, but sheet may be furnished not oiled if required. 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 which type of oil 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.

NOTE If AR and DO are omitted, it means that the delivery will be as-rolled.

## 5.9 Dimensional and shape tolerances

**5.9.1** Dimensional and shape tolerances applicable to hot-rolled steel sheet in coils of structural quality heavy thickness shall be as specified in [Tables 5](#) and [6](#). These tolerances also apply to descaled material.

5.9.2 Edge camber shall not exceed 25 mm in any 5 000 mm of length (see [Figure 1](#)).

**Table 4 — Mechanical properties**

Grade	$R_e^a$ min. MPa <sup>c</sup>	$R_m$ min. MPa <sup>c</sup>	$A^b$ min, %			
			$L_o = 5,65\sqrt{S_o}$	$L_o = 50$ mm for sheet thickness		
				$6 < e \leq 12$ mm	$12 < e \leq 19$ mm	$19 < e \leq 25$ mm
HR185	185	290	19	20	23	26
HR235	235	400	19	20	23	26
HR275	275	410	16	17	20	22
HR295	295	470	15	16	19	21
HR325	325	490	15	16	19	21
HR355	355	490	15	16	19	21

$R_e$  = yield strength – can be either  $R_{eL}$  or  $R_{eH}$  not both;  
 $R_{eL}$  = lower yield strength,  $R_{eH}$  = high 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;  
 $e$  = thickness of steel sheet, in millimetres.

<sup>a</sup> 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 strength (proof strength under load) or by 0,2 % offset when a definite yield phenomenon is not present.

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

<sup>c</sup> 1 MPa = 1 N/mm<sup>2</sup>

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

Dimensions and tolerances in millimetres

Specified widths	Specified thicknesses <sup>a</sup>				
	$6,00 < e \leq 8,00$	$8,00 < e \leq 10,00$	$10,00 < e \leq 12,50$	$12,50 < e \leq 16,00$	$16,00 < e \leq 25,00$
$600 < w \leq 1\ 200$	±0,29	±0,32	±0,35	±0,38	±0,40
$1\ 200 < w \leq 1\ 500$	±0,30	±0,33	±0,36	±0,39	±0,42
$1\ 500 < w \leq 1\ 800$	±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;  
 $e$  = thickness of steel sheet, in millimetres;

NOTE 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:

$$l = \frac{90}{e} \text{ metres}$$

provided that the result was not greater than 20 m inclusive of both ends.

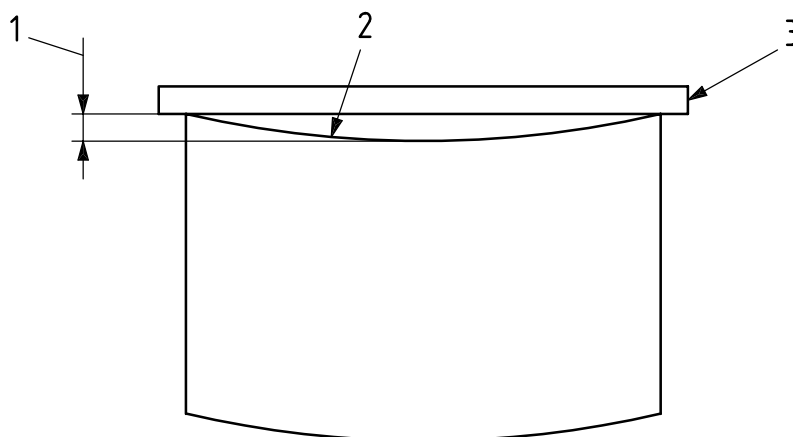
<sup>a</sup> Thickness is measured at any point on the sheet not less than 40 mm from a side edge for mill edge material and not less than 25 mm from the edge for sheared edge material.

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

Dimensions and tolerances in millimetres

Specified widths	Mill edges		Sheared edges	
$\geq 600 < w \leq 1\,200$	+28	0	+5	0
$\geq 1\,200 < w \leq 1\,500$	+38	0	+6	0
$\geq 1\,500 < w \leq 1\,800$	+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**

## 6 Sampling — Tensile test

One representative transverse sample from each 50 t or less for shipment shall be taken for the tensile test to verify conformance to the requirements of [Table 4](#).

## 7 Test methods

### 7.1 Tensile test

The tensile test shall be conducted in accordance with the methods specified in ISO 6892-1. Transverse test pieces shall be taken midway between the centre and the edge of the as-rolled sheet.

### 7.2 Impact test

While not usually specified, if so agreed at the time of ordering, impact tests may be specified for material over 12,5 mm in thickness. The test piece shall be in the longitudinal direction and the test shall be carried out in accordance with ISO 148-1.

## 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 shall be substituted.

### 8.2 Elongation

On any tensile test, 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 carried out.

### 8.3 Additional tests

If any test does not give the specified results, two additional tests shall be conducted on samples selected at random from the same lot. Both retests shall conform to the requirements of document; otherwise the lot shall be rejected.

## 9 Resubmission

**9.1** The manufacturer has the right to 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, etc.) which, on request, will be indicated to the purchaser. In this case, tests shall be carried out as if they applied to a new lot.

**9.2** The manufacturer has the right to present the rejected products for re-examination for compliance with the requirements for another grade.

## 10 Workmanship

**10.1** The surface condition shall be that normally obtained for a hot-rolled product.

**10.2** Processing for shipment in coils does not afford the manufacturer the opportunity to observe readily or remove non-conforming portions, as is possible on cut length products. However, this does not relieve the manufacturer of responsibility to provide a product that meets the requirement for surface condition that is normally obtained on a hot-rolled product.

## 11 Inspection and acceptance

**11.1** Although not usually required for products covered by this document, when the purchaser specifies that inspection and tests for acceptance shall 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.

**11.2** Steel that is reported to be non-conforming 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 the reported non-conforming material may be properly investigated.

## 12 Coil size

When ISO 13976 is ordered in coils. A minimum or range of acceptable inside diameter(s) (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.

### 13 Marking

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

- a) the manufacturer's name or identifying brand;
- b) a reference to this document, i.e. ISO 13976:2016;
- c) the grade designation;
- d) the order number;
- e) the product dimensions;
- f) the lot number;
- g) the mass;
- h) the coil number.

### 14 Information to be supplied by the purchaser

To specify requirements adequately according to this document, inquiries and orders shall include the following information:

- a) a reference to this document, i.e. ISO 13976:2016;
- b) the name and grade of the material (for example, hot-rolled steel sheet in coils, structural quality, grade HR275);
- c) the dimensions of the product and the quantity required;
- d) the application (name of part) when available (see [5.5](#));
- e) whether pickling or descaling by grit or shot blasting is required.

NOTE The material specified to be pickled or descaled will be oiled unless ordered unoled (see [3.3](#) and [5.8](#));

- f) the type of edge (see [3.4](#) and [3.5](#));
- g) whether cropped ends are required;
- h) the report of the heat analysis and mechanical properties, if required (see [5.4](#) and [5.3.1](#));
- i) limitations on masses and dimensions of individual coils if applicable (see [Clause 12](#));
- j) inspection and tests for acceptance prior to shipment from the manufacturer's works, if required (see [11.1](#)).

EXAMPLE A typical ordering description is as follows:

International Standard 13976:2016, hot-rolled steel sheet in coils, structural quality, heavy-thickness, grade HR275, 12 mm × 1 200 mm × coil, 40 000 kg, for a hinge part No 3 456, pickled, descaled and oiled (DO), mill edge, cropped, furnish report of mechanical properties, maximum coil 20 000 kg, coil ID 760 mm, maximum OD 1 850 mm.

## Bibliography

- [1] ASTM A1018, *M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability*<sup>1)</sup>

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