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Hot-rolled steel strip of structural quality

Feuillards laminés à chaud en acier de construction

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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 6316 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 6316:2000), which has been technically revised.

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Hot-rolled steel strip of structural quality

1 Scope

1.1 This International Standard specifies requirements for hot-rolled steel strip of structural quality in the grades and classes listed in Table 1, usually without the use of microalloying elements. This 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. It is commonly rolled on a narrow strip mill.

1.2 This product is commonly produced in thicknesses from 0,65 mm to 12 mm inclusive and widths up to 600 mm exclusive, in coils and cut lengths.

1.3 This International Standard does not cover steels designated as commercial quality or drawing quality (covered in ISO 6317, *Hot-rolled carbon steel strip of commercial and drawing qualities*) or steels intended for boilers or pressure vessels, or steels to be rerolled to cold-reduced products, or steels designated as weathering steels, having increased atmospheric corrosion resistance.

1.4 Hot-rolled steel strip can also be rolled on a wide continuous mill and slit into narrower coils. However, all attributes of the finished product meet the requirements of 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 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.

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 with equivalent strength levels

3.2

hot-rolled steel strip

product obtained by rolling heated steel (billet or slab) through a continuous-type mill to the required strip thickness, tolerances and other attributes set in this International Standard

NOTE The product has a surface covered with oxide or scale resulting from the hot-rolling operation.

3.3 hot-rolled descaled steel strip

hot-rolled steel strip from the surface of which oxide or scale has been removed, commonly by pickling in an acid solution

NOTE 1 Descaling may 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 This product is normally supplied oiled.

3.4 mill edge

normal side edge without any definite contour produced in hot rolling

NOTE 1 Mill edges may contain some irregularities, such as cracked or torn edges or thin (leathered) edges.

NOTE 2 A square mill edge can be produced by hot-edge rolling (with the corners not as square as a square-edge bar).

3.5 sheared edge

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

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

4 Conditions of manufacture

4.1 Steelmaking

The processes used in steelmaking and in manufacturing hot-rolled strip 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 be as agreed upon between the interested parties at the time of ordering. The ranges or limits shall be in accordance with the requirements of Tables 1 and 2 for the designation specified.

Table 1 — Chemical composition (heat analysis)

Mass fractions in percent

Grade	Class ^{a,b}	Method of deoxidation ^{c, d}	C max.	Mn max.	Si max.	P max.	S max.
HR235	B	E or NE	0,18	1,20	Not applicable	0,035	0,035
	D	CS	0,17	1,20	0,25	0,035	0,035
HR275	B	E or NE	0,21	1,20	Not applicable	0,035	0,035
	D	CS	0,20	1,20	0,25	0,035	0,035
HR355	B	NE	0,21	1,60	0, 55	0,035	0,035
	D	CS	0,20			0,035	0,035

^a Class B steels are intended for use in welded structures or structural parts subjected to normal loading conditions.
^b Class D steels are intended for use in welded structures or structural parts where, owing to loading conditions and the general design of the structure, a high resistance to brittle fracture is necessary.
^c E = rimming; NE = non-rimming; CS = aluminum killed.
^d The mass fraction of nitrogen is controlled; normally it should not exceed 0,009 % for E or NE steel or 0,015 % for CS steel.

Table 2 — Limits on additional chemical elements

Mass fractions in percent

Elements	Heat analysis	Product analysis
	max.	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
Nb ^c	0,008	0,018
V ^c	0,008	0,018
Ti ^c	0,008	0,018

^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/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 is/are specified, the sum does not apply; in which case, only the individual limits on the remaining elements apply.

^c Analysis greater than 0,008 % may be supplied after agreement between the producer and purchaser.

4.3 Chemical analysis

4.3.1 Heat analysis

A heat analysis of each heat of steel shall be made by the manufacturer to determine compliance with the requirements of Tables 1 and 2. When requested at the time of ordering, this analysis shall be reported to the purchaser or his representative. Each of the elements listed in Table 1 shall be included in the report of the heat analysis. If one or more of the elements in Table 2 is/are specified, the analysis shall be reported.

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

4.4 Weldability

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

4.5 Application

Hot-rolled steel strip should 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 4, when they are determined on test pieces obtained in accordance with the requirements of Clause 6.

4.7 Surface condition

Oxide or scale on hot-rolled steel strip 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. Also, after drawing, imperfections may be visible which were not apparent in the flat strip.

4.8 Oiling

As a deterrent to rusting, a coating of oil is usually applied to the descaled product. The oil is not intended as a drawing or forming lubricant and shall be easily removable with degreasing chemicals. The product may be ordered not oiled if required, in which case, the supplier has limited responsibility if oxidation occurs.

Table 3 — Product analysis tolerances

Element	Maximum of specified element %	Tolerance over maximum specified %
Carbon	> 0,15 to ≤ 0,40	0,04
Manganese	> 1,15 to ≤ 1,65	0,05
Silicon	> 0,30 to ≤ 0,60	0,05
Phosphorus	≤ 0,04	0,01
Sulfur	≤ 0,04	0,01

NOTE The above maximum tolerance is the allowable excess over the specified requirements, and not the heat analysis.

Table 4 — Mechanical properties

Grade	R_e min. ^a MPa	R_m min. (for information only) MPa	A % min. ^{b, c}			
			$e < 3$		$3 \leq e \leq 6$	
			$L_o = 50$ mm	$L_o = 80$ mm	$L_o = 5,65 \sqrt{S_o}$	$L_o = 50$ mm
HR235	235	330	20	18	23	22
HR275	275	370	17	15	20	18
HR355	355	450	15	13	19	16

R_e 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
 1 MPa = 1 N/mm²

^a The yield strength can be measured either by 0,5 % total elongation proof stress $R_{t0,5}$ (proof stress under load) or by 0,2 % offset $R_{p0,2}$ 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 of 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.
^c For material over 6 mm in thickness, values for elongation are subject to agreement between the manufacturer and purchaser.

5 Dimensional tolerances

Dimensional tolerances applicable to hot-rolled steel strip of structural quality shall be as given in Table 5 and Tables 7 to 10 inclusive.

Restrictive thickness tolerances are given in Table 6.

It has not been found practicable to formulate flatness and out-of-square tolerances for hot-rolled steel strip.

6 Sampling

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

7 Test methods

7.1 Tensile test

The tensile test shall be carried out in accordance with ISO 6892-1. Longitudinal test pieces shall be taken at the 1/4 point (halfway between the edge and mid-width).

7.2 Impact test

While not usually specified, if so agreed at the time of ordering, impact tests may be specified for material over 6 mm in thickness. The test piece shall be in the longitudinal direction and the test shall be a Charpy V-notch test 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 substituted.

8.2 Elongation

If the percentage elongation of any test piece is less than that specified in Table 4, or 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

The manufacturer may resubmit, for acceptance, the products that have been rejected during earlier inspection because of unsatisfactory properties, after they have been subjected to suitable retreatment (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 Workmanship

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

The steel strip in cut lengths shall be free from 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 imperfect portions as can be carried out on the cut-length product.

11 Inspection and acceptance

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 provide the purchaser's inspector with all reasonable facilities to determine that the steel is being furnished in accordance with this International Standard.

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

12 Coil size

When hot-rolled steel strip 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.

13 Marking

Unless otherwise stated, the following minimum requirements for identifying the steel shall be legibly stenciled 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 the requirements of this International Standard, enquiries and orders shall include the following information:

- a) a reference to this International Standard, i.e. ISO 6316;
- b) the name, quality, grade and class of the material (for example, hot-rolled steel strip, structural quality, grade HR235, class D);
- 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 and 4.8);
- 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/or the mechanical properties, if required (see 4.3.1 and 4.6);
- i) limitations on mass and dimensions of individual coils or bundles, if applicable (see Clause 12);
- j) inspection and tests for acceptance prior to shipment from the manufacturer's works, if required (see Clause 11).

NOTE A typical ordering description is as follows:

ISO 6316, hot-rolled steel strip, structural quality, grade HR235, class D, 3 mm × 200 mm × 1 600 mm, 40 000 kg, for part No. 2343 roof support, mill edge, furnish report of mechanical properties, maximum lift mass 1 000 kg.

Table 5 — Normal thickness tolerances for hot-rolled structural-quality steel strip (including descaled strip), coils and cut lengths

Values in millimetres

Grade	Thickness tolerances for specified thicknesses ^a								
	Specified width	$e \leq 1,5$	$1,5 < e \leq 2$	$2 < e \leq 4$	$4 < e \leq 5$	$5 < e \leq 6$	$6 < e \leq 8$	$8 < e \leq 10$	$10 < e \leq 12$
HR235 and HR275 (including descaled strip and coils)	≥ 10	$\pm 0,12$	$\pm 0,14$	$\pm 0,15$	$\pm 0,16$	$\pm 0,17$	$\pm 0,18$	$\pm 0,19$	—
	< 100								
HR355 (including descaled material)	≥ 100	$\pm 0,14$	$\pm 0,16$	$\pm 0,17$	$\pm 0,18$	$\pm 0,19$	$\pm 0,20$	$\pm 0,22$	$\pm 0,27$
	< 600								
HR355 (including descaled material)	≥ 10	$\pm 0,13$	$\pm 0,15$	$\pm 0,17$	$\pm 0,18$	$\pm 0,19$	$\pm 0,20$	$\pm 0,21$	—
	< 100								
HR355 (including descaled material)	≥ 100	$\pm 0,15$	$\pm 0,18$	$\pm 0,19$	$\pm 0,20$	$\pm 0,21$	$\pm 0,22$	$\pm 0,24$	$\pm 0,30$
	< 600								

NOTE The values specified do not apply to the uncropped ends of a mill-edge coil within 7 m inclusive of either end.

^a The thickness is measured at any point on the strip, not less than 20 mm from a side edge for mill-edge strip, and not less than 10 mm from a side edge for edge-trimmed strip. Measurements shall not be made on top of the shear burr.

Table 6 — Restrictive thickness tolerances for hot-rolled structural-quality steel strip (including descaled strip), coils and cut lengths

Values in millimetres

Grade	Thickness tolerances for specified thicknesses ^a								
	Specified width	$e \leq 1,5$	$1,5 < e \leq 2$	$2 < e \leq 4$	$4 < e \leq 5$	$5 < e \leq 6$	$6 < e \leq 8$	$8 < e \leq 10$	$10 < e \leq 12$
HR235 and HR275 (including descaled strip and coils)	≥ 10 < 100	$\pm 0,09$	$\pm 0,10$	$\pm 0,11$	$\pm 0,12$	$\pm 0,13$	$\pm 0,14$	$\pm 0,14$	—
	≥ 100 < 600	$\pm 0,10$	$\pm 0,12$	$\pm 0,13$	$\pm 0,14$	$\pm 0,14$	$\pm 0,15$	$\pm 0,17$	$\pm 0,20$
HR355 (including descaled material)	≥ 10 < 100	$\pm 0,10$	$\pm 0,11$	$\pm 0,13$	$\pm 0,14$	$\pm 0,14$	$\pm 0,15$	$\pm 0,16$	—
	≥ 100 < 600	$\pm 0,11$	$\pm 0,14$	$\pm 0,14$	$\pm 0,15$	$\pm 0,16$	$\pm 0,17$	$\pm 0,18$	$\pm 0,23$

NOTE The values specified do not apply to the uncropped ends of a mill-edge coil within 7 m inclusive of either end.

^a The thickness is measured at any point on the strip not less than 20 mm from a side edge for mill-edge strip and not less than 10 mm from a side edge for edge-trimmed strip. Measurements shall not be made on top of the shear burr.

Table 7 — Width tolerances for hot-rolled steel strip (including descaled strip), mill-edge coils and cut lengths

Values in millimetres

Specified width	Tolerance
≤ 50	$\pm 0,8$
$> 50 \leq 100$	$\pm 1,2$
$> 100 \leq 200$	$\pm 1,6$
$> 200 \leq 400$	± 2
$> 400 \leq 600$	$\pm 2,5$

NOTE 1 The values specified do not apply to the uncropped ends of a mill-edge coil within 7 m inclusive of either end.

NOTE 2 By agreement between the manufacturer and purchaser, material can be ordered to all plus tolerances, in which case, the value in the table is doubled.