

International Standard



630

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Structural steels

Aciers de construction métallique

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Structural steels

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies qualities for the general purpose structural steels listed in table 1.

It applies to steel plates with thicknesses of 3 mm and over, wide strip in coils wider than or equal to 600 mm wide, and greater than 6 mm in thickness, wide flats, bars and hot-rolled sections including hollow sections¹⁾ generally used in the as-delivered condition and normally intended for bolted, riveted or welded structures.²⁾

It does not cover the following steels, certain of which are covered by other International Standards :

- steels for boilers and pressure vessels (ISO 2604/4);
- plates of drawing quality (ISO 3573 and ISO 3574);
- heat-treated (quenched and tempered) structural steels;
- bars for the reinforcement of concrete;
- strip of width greater than or equal to 600 mm and thickness equal to or less than 6 mm (ISO 4995).

2 REFERENCES

ISO 82, *Steel — Tensile testing*.

ISO/R 85, *Bend test for steel*.

ISO 148, *Steel — Charpy impact test (V-notch)*.³⁾

ISO/R 202, *Flattening test on steel tubes*.

ISO 375, *Steel — Tensile testing of tubes*.

ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel*.

ISO 404, *Steel and steel products — General technical delivery requirements*.⁴⁾

ISO 2566/1, *Steel — Conversion of elongation values — Part 1 : Carbon and low-alloy steels*.

ISO 2604/4, *Steel products for pressure purposes — Quality requirements — Part 4 : Plates*.

ISO 3573, *Hot-rolled carbon steel sheet of commercial and drawing qualities*.

ISO 3574, *Cold-reduced carbon steel sheet of commercial and drawing qualities*.

ISO 4995, *Hot-rolled steel sheet of structural quality*.

3 DEFINITIONS

Definitions of the terms "plates", "wide strip (coils)", "strips and wide flats" are in course of preparation.

4 GENERAL REQUIREMENTS

4.1 Steelmaking method

Unless otherwise agreed at the time of enquiry and order, the steelmaking method is left to the choice of the manufacturer; except for qualities 0 and A the purchaser shall be informed of the method at the time of delivery provided that this was so requested at the time of order.

4.2 As-delivered condition

The products are generally delivered in the as-rolled condition. Other as-delivered conditions may form the subject of agreement when ordering. However, flat products of quality D as listed in 6.4.1 shall be delivered in the normalized condition or in an equivalent condition obtained by controlled rolling, unless otherwise agreed on the order.

1) For hollow sections, the term "hot finished" is synonymous with "hot rolled".

2) For precautions to be taken when welding, the guide for the welding and weldability of C-Mn and C-Mn micro-alloy steels published by Sub-commission IX-G of the International Welding Institute may be helpful (document IIS/IW 382-71).

3) At present at the stage of draft. (Revision of ISO/R 148.)

4) At present at the stage of draft. (Revision of ISO/R 404.)

4.3 Surface appearance — Defects

4.3.1 Surface appearance

The products shall have a smooth surface corresponding to the rolling method used; they shall have no defects that are prejudicial to their subsequent processing or their intended end use.

4.3.2 Removal of defects

4.3.2.1 Repair by grinding

Less important defects may be removed by the producer by grinding, provided that the thickness is not reduced locally by more than 7 % (with a maximum of 3 mm) in relation to its nominal value. Reductions greater than 4 %, but not exceeding 7 %, may be made only with the agreement of the purchaser.

4.3.2.2 Repair by welding

Unless otherwise specified, imperfections that are greater in depth than the limits specified in 4.3.2.1 may be removed and then weld metal deposited subject to the following limiting conditions :

- a) The total area of the surface of any piece so repaired prior to welding shall not exceed 2 % of the total surface area of that piece.
- b) The reduction of thickness of the material resulting from removal of imperfections prior to welding shall not exceed 20 % of the nominal thickness at the location of the imperfection nor shall the depth of the depression prior to welding exceed 30 mm in any case.
- c) The toes of angles, beams, channels and Z sections and the stems and tees of tees may be conditioned by grinding, chipping or air-arc gouging and welding. Prior to welding, the depth of the depression measured from the toe inward, shall be limited to the thickness of the material at the base of the depression, with a maximum depth limit of 13 mm.
- d) The edges of plates may be conditioned by the manufacturer to remove injurious imperfections by grinding, chipping or air-arc gouging and welding. Prior to welding, the depth of the depression measured from the plate edge inward shall be limited to the thickness of the plate, with a maximum depth of 25 mm.
- e) The reduction of sectional dimension of a round, square or hexagon bar, or the reduction in thickness of a flat bar, resulting from removal of an imperfection prior to welding, shall not exceed 5 % of the nominal dimension or thickness at the location of the imperfection.
- f) For the edges of flat bars, the depth of the defect prior to welding shall be measured from the edge inward and shall be limited to a maximum depth equal to the thickness of the flat bar or 13 mm whichever is less.
- g) All welding shall be performed by competent welders using hydrogen-controlled welding electrodes appropriate

for the grade being repaired. The electrodes shall be protected from moisture during storage and use.

- h) The manufacturer shall establish and follow documented welding procedures which are appropriate for the material being welded.

4.3.2.3 Repair quality

The welds and adjacent heat affected zone shall be sound and free of cracks, the weld metal being thoroughly fused to all surfaces and edges without undercutting or overlap. Any visible cracks, porosity, lack of fusion or undercut in any layer shall be removed prior to deposition of the succeeding layer. Weld metal shall project at least 2 mm above the rolled surface after welding, and the projecting metal shall be removed by chipping or grinding, or both, to make it flush with the rolled surface, and to produce a workmanlike finish.

4.3.2.4 Inspection of repair

The manufacturer shall maintain an inspection programme to inspect the work to ensure that :

- a) imperfections have been completely removed (inspection by means of visual, ultrasonic, magnetic, radiographic or penetrant dye methods, etc.);
- b) the limitations specified above have not been exceeded;
- c) established welding procedures have been followed;
- d) any weld deposit is of acceptable quality as defined above.

4.3.2.5 Heat treatment after repair by welding

If the welding repair has been carried out on a product already normalized, another normalizing treatment is always necessary. Retesting after re-normalizing is not required. For flat products, if the repair by welding has been carried out on a product in the "as rolled" condition, a stress-relieving or normalizing treatment may be desirable.

5 CHARACTERISTICS OF GRADES AND QUALITIES

5.1 Chemical composition

5.1.1 Ladle analysis

The composition limits for analysis carried out on samples taken during casting are given in table 1 and are maximum values.

5.1.2 Product analysis

The product analysis may be requested by the purchaser; in which case this shall be specified on the order. Table 2 gives the permitted deviations on analysis relative to the values for ladle analysis which are given in table 1.

Table 1 — Chemical composition (ladle analysis)

Grade	Quality	Thickness <i>e</i> mm	C % max.	P % max.	S % max.	N ₂ % ¹⁾ max.	Method of deoxidation ²⁾
Fe 310	0						
Fe 360	A	≤ 16 > 16	0,20	0,060	0,050	0,009	NE GF
	B		0,18	0,050	0,050		
	C		0,20				
	D		0,17	0,045	0,045		
Fe 430 ³⁾	A	≤ 40 > 40	0,24	0,060	0,050	0,009	NE GF
	B		0,21	0,050	0,050		
	C		0,22				
	D		0,20	0,045	0,045		
Fe 510 ⁴⁾	B	≤ 16 > 16 ≤ 35 > 35	0,22	0,050	0,050		NE NE GF
	C		0,20	0,045	0,045		
			0,22				
	D		0,20	0,040	0,040		

1) For steel treated with aluminium, the maximum nitrogen content may be increased to 0,015 %. The nitrogen contents are specified but they will be verified only if this is stated on the order. For steel made in an electric furnace the maximum value can be 0,012 %.

2) NE = non-rimming.

GF : These steels shall have a content of elements sufficiently high to produce a fine-grain structure, for example total aluminium greater than 0,02 %.

3) During a transition period, and subject to agreement between the parties concerned, grade Fe 410 may be supplied in place of grade Fe 430.

4) The contents for Mn and Si shall not exceed 1,60 % and 0,55 % respectively.

Table 2 — Permissible deviation for the product analysis in relation to the specified ladle analysis

Element	Specified limits	Permissible deviation	
		Rimming steel	Non-rimming steel
C	≤ 0,24	+ 0,05	+ 0,03
P	≤ 0,060	+ 0,015	+ 0,005
S	≤ 0,050	+ 0,015	+ 0,005
Mn	≤ 1,60		+ 0,10
Si	≤ 0,55		+ 0,05
N ₂	≤ 0,009	+ 0,002	+ 0,002

5.2 Mechanical properties

The steels in the delivery condition as defined in 4.2 shall comply with the mechanical properties specified in table 3 when these are determined on test pieces selected in accordance with 6.4.

For products over 63 mm in thickness, the mechanical properties shall be the subject of an agreement between the interested parties.

6 ACCEPTANCE TESTING

6.1 Rolled products covered by this International Standard may be the subject of acceptance tests in accordance with

the conditions specified in clause 5 of ISO/R 404 relating to the mechanical properties and chemical analysis of the product. However, it is not customary to request an acceptance test for grade Fe 310. Verification of chemical composition on the product and of the impact values at ambient temperature is only carried out by agreement at the time of enquiry and order.

6.2 If acceptance testing has been specified on the order, the acceptance test unit shall be formed either

a) by batch¹⁾ : all grades or qualities, except qualities C and D;

b) by cast : all grades and qualities.

It shall be stated on the order whether the batch method or the cast method of test unit formation is required.

Table 3 – Mechanical properties

Grades	Qualities	Yield strength, min.			$R_m^{1)}$ N/mm ²	$A_{\min}^{2)}$ $L_0 = 5,65\sqrt{S_0}$ %	180° bend mandrel ³⁾⁴⁾ diameter	Impact test (V-notch)	
		$e \leq 16$ N/mm ²	> 16 ≤ 40 N/mm ²	> 40 ≤ 63 N/mm ²				Test temper- ature °C	Energy ⁵⁾ min. J
Fe 310	0	175	175		310 to 510	17	3 e	—	—
Fe 360	A	235	225	215	360 to 460	25	2 e	—	—
	B	235	225	215		25	2 e	+ 20	27 ³⁾
	C	235	225	215		25	2 e	0	27
	D	235	225	215		25	2 e	— 20	27
Fe 430 ⁶⁾	A	275	265	255	430 to 530	22	3 e	—	—
	B	275	265	255		22	3 e	+ 20	27 ³⁾
	C	275	265	255		22	3 e	0	27
	D	275	265	255		22	3 e	— 20	27
Fe 510		$e \leq 16$	16-35	35-50	490 to 630				
	B	355	345	335		21	3 e	+ 20	27 ³⁾
	C	355	345	335		21	3 e	0	27
	D	355	345	335		21	3 e	— 20	27

1) For the tensile strength of wide strip (coils) only the minimum value of the range is applicable.

2) For transverse test pieces (plates and wide flats of width 600 mm and over) these values shall be reduced by two points.

3) This test is only carried out if specified in the order.

4) For transverse test pieces (plates and wide flats of width of 600 mm and over) these values are increased by 0,5 e, except for grade Fe 310.

5) Average of three tests; no individual result shall be less than 70 % of the specified minimum average value.

6) For a transitional period only, grade Fe 410 may be delivered in the place of grade Fe 430, by agreement at time of order. The properties for grade Fe 410 shall be the subject of agreement on the order.

NOTE — 1 N/mm² = 1 MPa

1) A batch is defined as the output of one or more casts of the same grade and same quality rolled into one class of product and submitted for acceptance at the same time.

6.3 Acceptance test unit

6.3.1 The acceptance test unit (or lot) shall be :

- 20 tonnes or fraction thereof for acceptance by batch.
- 50 tonnes or fraction thereof for acceptance by cast.

6.3.2 For each acceptance test unit or thickness range, as defined in table 3, the series of tests shall be carried out comprising :

- one tensile test (or more, in accordance with 6.3.4.1 in the case of products up to and including 16 mm thick);
- one set of three impact tests at 0 °C for quality C and one set of three tests at – 20 °C for quality D;

and, if specified on the order :

- one product analysis;
- one bend test (for hollow sections with dimensions of up to and including 410 mm, this test may be replaced by a flattening test);
- one set of three impact tests at 20 °C for quality B.

6.3.3 The purchaser or his representative may, at the time of rolling, choose the products from which the test samples for the verification of properties are selected.

6.3.4 Unless otherwise agreed the procedure shall be as follows :

6.3.4.1 Tensile test

For each specified thickness range test samples shall be taken from the thickest product, except that for the range $e \leq 16$ mm the thickness of products shall be such that the maximum thickness is not greater than twice the minimum thickness.

6.3.4.2 Impact test

For each thickness range, the test sample shall be taken from the thickest product.

For quality D, if agreed at the time of enquiry and order, a test sample shall be taken from each rolled piece.

6.4 Position and orientation of test pieces (see ISO/R 377)

6.4.1 Plates, wide strip (coils) and wide flats having a width equal to or greater than 600 mm

The test sample shall be taken mid-way between the centre line in the direction of rolling and edge of the rolled product.

6.4.1.1 The longitudinal axes of tensile and bend test pieces shall be perpendicular to the direction of rolling.

6.4.1.2 The longitudinal axes of impact test pieces shall always be parallel to the direction of rolling.

6.4.2 Sections and wide flats having a width of less than 600 mm

The longitudinal axes of the test pieces shall be parallel to the direction of rolling. However, if agreed, a transverse test piece may be used for widths between 450 and 600 mm.

For sections, the test samples shall be taken such that the axis of the test piece is 1/3 from the outer edge of the half-flange (for I beams) or of the flange (for other sections), or, in the case of small sections, as near as possible to this position (see the figure). In the case of tapered flange sections the test samples may be taken at the outer 1/4 position of the web.

6.4.3 Rounds, squares, flat bars, hexagons and other similar products

The longitudinal axes of test pieces shall be parallel to the direction of rolling.

For small sizes, the test piece shall consist of a length of the product.

In other cases, the test samples shall be so taken that the axis of the test piece, so far as is possible, is located :

- for squares and flat bars, at 1/3 of the half-width (from the outer face) or of the half-diagonal;
- for rounds and hexagons, at 1/3 from the outside of the half-diagonal or the half-diameter (see the figure).

6.4.4 Hollow sections (see figure)

For small sections, the test piece shall consist of a section of the product.

For round sections, the test piece shall be taken longitudinally at any point in the section.

For square or rectangular sections, the test piece shall be taken longitudinally mid-way between the corners.

For longitudinally welded hollow sections, the longitudinal test piece shall be taken outside the weld zone.

6.5 Test methods – Types of test pieces

6.5.1 Tensile test (see ISO 82 or ISO 375)

Normally the test piece used shall have a proportional prismatic or cylindrical shape and have an original gauge length given by the formula

$$L_0 = 5,65 \sqrt{S_0}$$

where S_0 is the original cross-sectional area.

The prismatic test piece of rectangular cross-section shall have a maximum width on the gauge length portion of 40 mm, its thickness being that of the product; however, if the thickness of the product exceeds 30 mm, it may be reduced to 30 mm by planing or milling on one face only.

The cylindrical test piece may be used for products more than 30 mm thick; it shall have a diameter of between 10 and 30 mm, the original gauge length being determined by the above formula.

A non-proportional test piece with a fixed original gauge length may also be used. In this case,

- a) if the gauge length is 200 mm
 - the value of the elongation for flat products is $A \% \geq 16$;
 - the value of the elongation for long products is $A \% \geq 18$ in the case of products with thicknesses greater than 8 mm, and $A \% \geq 16$ in the case of products with thicknesses up to and including 8 mm.
- b) For other gauge lengths, reference shall be made to a conversion table (see ISO 2566/1).

In case of dispute, however, only the results obtained on a proportional test piece shall be taken into consideration.

The yield strength specified in table 3 is either the upper yield stress, R_{eH} or the proof stress (0,5 % total elongation) $R_{t0,5}$. The specification of the material is complied with in this respect if either value satisfies the specified value of yield strength.

6.5.2 Bend test (see ISO/R 85, if specified)

The test piece shall be of rectangular section and have a width greater than or equal to 30 mm. Its thickness shall be that of the product, but it may, if the thickness of the product exceeds 30 mm, be reduced to 30 mm by planing on one face only. In this case, the bend shall be made so that the remaining rolled surface is on the outside of the bend.

In the case of circular hollow sections with outer dimensions less than 410 mm, the bend test may be replaced by a flattening test carried out in accordance with ISO/R 202.

For circular hollow sections, bending is in the direction of the curve of the test piece; for square and rectangular hollow sections, bending is parallel to the axis of the section.

6.5.3 Impact test

6.5.3.1 The impact test shall normally be carried out on products having a thickness greater than or equal to 12 mm or diameter greater than or equal to 16 mm. The test piece shall be so machined that, for flat products, the face nearest to the rolled surface is not more than 2 mm from it; the notch shall be perpendicular to the rolled surface.

If agreed at the time of enquiry and order, impact tests may be carried out on products having a thickness less

than 12 mm; the dimensions of the test pieces shall be in accordance with the requirements of ISO/R 148, i.e. $10 \times 7,5$ mm and 10×5 mm, and the energy values to be guaranteed shall be fixed by agreement.

6.5.3.2 The test shall be carried out using a V-notch test piece supported at both ends (see ISO/R 148), the value to be taken into account being the average of the results obtained on three test pieces, but adjacent to each other from the same product, unless there are reasons for a retest (see 6.5.5).

6.5.4 Faulty tests and defective test pieces

When a test does not give the required results because of an error in execution the test shall be cancelled. Error in execution means incorrect machining, incorrect mounting in the testing machine, malfunction of this machine or any other anomaly independent of the metal itself.

If a defective test piece gives satisfactory results, the batch shall be accepted but the corresponding item (from which the test sample was taken) shall be submitted to an individual examination for soundness.

6.5.5 Retests

If during inspection, the required values are not achieved, additional tests unless otherwise agreed, may be carried out as follows :

6.5.5.1 Tensile test and bend test (if specified)

- a) If a test piece does not give the required values, the corresponding item is deemed not to comply with the specification, unless two other test pieces from the same item are tested and give satisfactory results. In this case, the item and the batch are considered to comply with the specification.
- b) If one or both of the additional test pieces do not satisfy the requirements, the corresponding item is deemed not to comply with the specification.

6.5.5.2 Impact test

- a) If the average of the three impact values is less than the specified value, or if one individual value is below 70 % of this specified value, three supplementary test pieces shall be taken from the same item and shall be submitted to a test. The average value of the six results shall not be less than the specified value. Not more than two individual values shall be less than the specified value and only one individual value may be lower than 70 % of this value.
- b) If an item presented for the first time is not considered to comply with the specification, the remainder of the material may be accepted provided that two other representative items are tested in accordance with the specification and give satisfactory results.