INTERNATIONAL STANDARD

ISO 6930-1

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High yield strength steel plates and wide flats for cold forming —

Part 1: Delivery conditions for thermomechanically-rolled steels

Tôles et larges-plats en acier à haute limite d'élasticité pour formage à froid —

Partie 1: Conditions de livraison des aciers à l'état de laminage thermomécanique

Reference number
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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 3.

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 part of ISO 6930 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 6930-1 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 3, *Steels for structural purposes*.

This first edition, together with ISO 6930-2, cancels and replaces ISO 6930:1983, all clauses of which have been modified, especially clauses 1, 5, 6, Tables 1, 2, 3 and annex A, which has been technically revised.

ISO 6930 consists of the following parts, under the general title *High yield strength steel plates and wide flats for cold forming*:

— *Part 1: Delivery conditions for thermomechanically-rolled steels*

— *Part 2: Delivery conditions for normalized, normalized rolled and as-rolled steels*

Annex A of this part of ISO 6930 is for information only.

High yield strength steel plates and wide flats for cold forming —

Part 1:
Delivery conditions for thermomechanically-rolled steels

1 Scope

1.1 This part of ISO 6930 specifies the requirements for weldable high yield strength steels for cold forming.

This part of ISO 6930 applies to plate hot-rolled on reversing mills and to hot-rolled wide-flats both having a thickness between 4 mm and 20 mm inclusive and supplied in the thermomechanically rolled delivery condition.

1.2 This part of ISO 6930 does not apply to weldable structural steels, whether or not of special quality, which are covered by other International Standards, namely:

— high yield strength steel produts for cold forming delivered in normalized, normalized rolled and as-rolled condition (ISO 6930-2);

— structural steels (ISO 630);

— high yield strength flat steel products (ISO 4950-1, ISO 4950-2 and ISO 4950-3);

— hot-rolled steel sheet of higher yield strength with improved formability (ISO 5951).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 6930. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 6930 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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

ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*.

ISO 404:1992, *Steel and steel products — General technical delivery requirements*.

ISO 2566-1:1984, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels*.

ISO 6892, *Metallic materials — Tensile testing at ambient temperature*.

ISO 7438, *Metallic materials — Bend test*.

ISO/TR 9769, *Steel and iron — Review of available methods of analysis*.

ISO 10474, *Steel and steel products — Inspection documents*.

ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition*.

3 Terms and definitions

For the purposes of this part of ISO 6930, the following terms and definitions apply.

3.1
thermomechanical rolling
rolling process in which the final deformation is carried out in a certain temperature range leading to a material condition with certain properties which cannot be achieved or repeated by heat treatment alone

NOTE 1 Subsequent heating above 580 °C may lower the strength values. If temperatures above 580 °C are needed, the supplier should be informed.

NOTE 2 Thermomechanical rolling leading to the delivery condition “thermomechanically rolled” can include processes with an increasing cooling rate with or without tempering including self-tempering but excluding direct quenching and quenching and tempering.

3.2
thermomechanically rolled steel
steel obtained by thermomechanical rolling

3.3
wide flat
finished flat product of width greater than 150 mm and a thickness generally over 4 mm, always supplied in lengths, i.e. not coiled and whose edges are sharp

NOTE The wide flat is hot-rolled on the four sides (or in box passes) or produced by shearing or flame-cutting wider flat produtcs. Wide flats rolled on all four sides are sometimes termed universal plates.

[ISO 6929:1987]

4 General requirements

4.1 Steelmaking process

Unless otherwise specified at the time of the enquiry and the order, the steelmaking process is left to the discretion of the manufacturer; it shall, however, be possible to disclose it to the purchaser, if he so requests, at the time of the delivery.

4.2 Method of deoxidation

The steels shall be fully killed and made to a fine grain practice.

4.3 Production process

Unless otherwise specified at the time of the enquiry and the order, the production process is left to the discretion of the manufacturer.

4.4 Delivery condition

Plates and wide flats are supplied in the thermomechanically rolled supply condition.

Unless specially agreed at the time of enquiry and order, the products are generally supplied with their surface as-rolled. On request, they may be delivered with descaled surfaces. However, the fact that certain descaling processes are liable to modify the cold forming properties shall be taken into account.

Descaled products may be delivered with their surfaces protected, by agreement with the purchaser.

The type of the protection shall be agreed at the time of the enquiry or order.

5 Technical requirements

5.1 Chemical composition

5.1.1 Ladle analysis

The composition limits for the ladle analysis are given in Table 1.

Table 1 — Chemical composition of thermomechanically rolled steels (ladle analysis)

Grades	C % max.	Mn % max.	Si % max.	P % max.	S % max.[a]	Al_{total} % min.[b]	Nb % max.[c]	V % max.[c]	Ti % max.[c]	Mo % max.	B % max.
FeE 315	0,12	1,3	0,5	0,025	0,020	0,015	0,09	0,2	0,15	—	—
FeE 355	0,12	1,5	0,5	0,025	0,020	0,015	0,09	0,2	0,15	—	—
FeE 420	0,12	1,6	0,5	0,025	0,015	0,015	0,09	0,2	0,15	—	—
FeE 460	0,12	1,6	0,5	0,025	0,015	0,015	0,09	0,2	0,15	—	—
FeE 500	0,12	1,7	0,5	0,025	0,015	0,015	0,09	0,2	0,15	—	—
FeE 550	0,12	1,8	0,5	0,025	0,015	0,015	0,09	0,2	0,15	—	—
FeE 600	0,12	1,9	0,5	0,025	0,015	0,015	0,09	0,2	0,22	0,50	0,005
FeE 650	0,12	2,0	0,6	0,025	0,015	0,015	0,09	0,2	0,22	0,50	0,005
FeE 700	0,12	2,1	0,6	0,025	0,015	0,015	0,09	0,2	0,22	0,50	0,005

[a] If agreed at the time of the enquiry and order the sulfur content shall be maximum 0,010 % (ladle analysis).

[b] If agreed at the time of enquiry and order the minimum content of total aluminium does not apply when other grain-refining elements are present in sufficient quantity.

[c] The sum of niobium, vanadium and titanium shall be maximum 0,22 %.

5.1.2 Product analysis

If requested by the purchaser at the time of enquiry and order, a product analysis shall be carried out.

Table 2 gives the permissible deviations of the product analysis from the specified limits of the ladle analysis given in Table 1.

5.2 Mechanical properties

5.2.1 The mechanical properties given in Table 3 apply to plates and wide flats supplied in the delivery condition given in 4.4 and are determined on test pieces in accordance with clause 6.

The mechanical properties for products having a thickness greater than 20 mm shall be the subject of agreement at the time of enquiry or order.

5.2.2 If agreed at the time of the enquiry and order, the impact energy value shall be verified at $-20\ ^{\circ}C$ and shall meet a minimum average value of 40 J based on a full size (10 mm $\times$ 10 mm) test piece (see 7.2). If the thickness is not sufficient for the preparation of full size impact test pieces, test pieces of smaller width shall be taken and the applicable values shall be decreased proportionally.

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

Element	Specified limits %	Permissible deviation[a]
C	$\leqslant$ 0,12	+ 0,02
Mn	$\leqslant$ 2,1	+ 0,1
Si	$\leqslant$ 0,6	+ 0,05
P	$\leqslant$ 0,025	+ 0,005
S	$\leqslant$ 0,020	+ 0,002
Al_{total}	$\geqslant$ 0,015	− 0,005
Nb	$\leqslant$ 0,09	+ 0,01
V	$\leqslant$ 0,20	+ 0,02
Ti	$\leqslant$ 0,22	+ 0,01
Mo	$\leqslant$ 0,5	+ 0,05
B	$\leqslant$ 0,005	+ 0,001

[a] The deviations apply either above or below the specified limits of the range, but not simultaneously. When maxima only are specified, the deviations are positive only.

Table 3 — Mechanical properties for thicknesses up to twenty millimetres

Grade	Minimum yield strength R_{eH} N/mm^2	Minimum tensile strength R_m N/mm^2	Minimum percentage elongation at fracture A % $L_o = 5{,}65\sqrt{S_o}$
FeE 315	315	390	24
FeE 355	355	430	23
FeE 420	420	480	19
FeE 460	460	520	17
FeE 500	500	550	14
FeE 550	550	600	14
FeE 600	600	650	13
FeE 650	650[a]	700	12
FeE 700	700[a]	750	12

[a] For thicknesses $>$ 8 mm the minimum yield strength can be 20 N/mm^2 lower.

5.3 Technical properties

5.3.1 Weldability

The steels are weldable by all appropriate processes provided the rules of the technology are followed.

A maximum value of the carbon equivalent (CEV) based on the ladle analysis can be agreed at the time of enquiry and order. The carbon equivalent value shall be determined using the following formula:

$$CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

5.3.2 Bending and cold-edging ability

Information about bending and cold-edging ability is given in annex A.

6 Inspection and testing

6.1 General

The product covered by this part of ISO 6930 shall be the subject of specific inspection and testing in accordance with the conditions specified in clause 8 of ISO 404:1992 relating to the chemical composition and mechanical properties of the product.

6.2 Test unit

6.2.1 General

The verification of product analysis and mechanical properties shall be per cast (heat).

6.2.2 Tensile properties

A test unit shall contain products of the same form, grade and delivery condition and be from the same thickness range.

For a test unit not exceeding 50 t, one tensile test shall be carried out. For a test unit exceeding 50 t, two tensile tests shall be carried out.

6.2.3 Impact tests

A test unit shall contain products of same form, grade and delivery condition.

For a test unit not exceeding 50 t, one set of impact tests shall be carried out. For a test unit exceeding 50 t, two sets of impact tests shall be carried out.

Tests shall be carried out at − 20 °C using sub-surface specimens from the thickest product. (See 5.2.2 for impact energy values.)

6.3 Position and orientation of sample

6.3.1 General

Sampling shall be carried out in such a way that the axis of the test piece is approximately equidistant from the centre line and the edge of the rolled product. See ISO 377.

6.3.2 Plate and wide-flat of width at least six hundred millimetres

The axis of the tensile test pieces shall be transverse to the direction of rolling if not otherwise agreed at enquiry.

The axis of the impact test pieces shall be parallel to the direction of rolling.

6.3.3 Wide-flat of width less than six hundred millimetres

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

7 Test methods

7.1 Tensile test

Normally the test piece used shall be a proportional prismatic test piece and have an original gauge length L_o given by the formula:

$$L_o = 5{,}65\sqrt{S_o}$$

where S_o is the original cross-sectional area of the gauge length.

See ISO 6892.

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.

A non-proportional test piece with fixed original gauge length may be used. In this case, reference shall be made to the conversion table in ISO 2566-1:1984.

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

The yield strength specified in Table 3 is the upper yield stress, R_{eH}. If the yield phenomenon is not visible either the 0,2 % proof stress, $R_{p0,2}$, or the 0,5 % total elongation $A_{t0,5}$ may be used.

The specification of the materials is complied with in this respect if either value satisfies the specified value of yield strength. In cases of dispute, the 0,2 % proof strength ($R_{p0,2}$) shall be determined.

7.2 Impact test

7.2.1 The impact test shall normally be carried out on products having a thickness $\geqslant$ 12 mm. The test piece shall be machined so that the face nearest to the rolled surface is not more than 1 mm from it; the notch shall be perpendicular to the rolling skin.

If agreed at the time of enquiry and order, impact tests may be carried out on products having a thickness between 6 mm and 12 mm inclusive. The dimensions of the test pieces shall be in accordance with the requirements of ISO 148, i.e. 10 mm $\times$ 7,5 mm or 10 mm $\times$ 5 mm or be 10 mm $\times$ t where t is the product thickness.

The minimum required energy value for the smaller test pieces shall be decreased proportionally to the test piece width.

7.2.2 The test shall be carried out using a V-notch test piece supported at both ends (see ISO 148), the value to be taken into account being the average of the results obtained from three test pieces adjacent to each other from the same product unless there are reasons for a retest (see 7.4).

7.3 Chemical analysis

7.3.1 If a product analysis is specified on the order, one sample shall be taken per cast unless otherwise specified on the order.

The samples may be taken from the test pieces used to check the mechanical properties or from the full thickness of the product at the same place as the test pieces. In case of dispute, only the analysis of material from the full thickness of the product shall be taken into consideration.

For the selection and preparation of samples for chemical analysis, the requirements of ISO 14284 shall be applied.

7.3.2 In case of dispute about analytical methods the chemical composition shall be determined in accordance with a reference method of ISO standards listed in ISO/TR 9769. If no standard exists, the method to be used shall be agreed between the parties concerned.

7.4 Retests

If, during inspection, a test does not give the required result, additional tests in accordance with ISO 404 shall be carried out.

8 Inspection documents

The type of inspection documents with respect to specific inspection and testing shall be chosen from those defined in ISO 10474 and specified in the order.

9 Sorting and reprocessing

The requirements of clause 9 of ISO 404:1992 shall apply.

10 Marking

Unless otherwise agreed at the time of order, products shall bear the following marks:

— the identification symbols for the grade of steel;

— the brand of the manufacturer;

— symbols, letters and numbers which relate the inspection document test pieces and products to each other.

In the case of products of small unit mass and which are consigned in bundles, the above information may be marked on a tag securely attached to each bundle (or it may be marked on the topmost item in the bundle, if appropriate).

11 Information to be supplied by the purchaser

In addition to the information mentioned in ISO 404, the following information shall be also given if applicable:

— the particular steelmaking process required (4.1);

— the particular production process required (4.3);

— if product analysis is required (5.1.2) and the number of samples required (7.3.1);

— if impact tests are required (6.2.3);

— the type of inspection document required (clause 8);

— other type of marking required (clause 10).

The non-supplied points shall not be taken into consideration by the manufacturer.

Annex A
(informative)

Bending and cold-edging of flat steel products

A.1 General

In general terms, and more particularly in the case of difficult bending operations, it is in the interests of the user to consult the manufacturer as to the choice of quality of steel and the conditions of use.

Furthermore, certain customary precautions shall be taken for grades FeE 500 to FeE 700 (removal of the shearing cross-section at right angles to the folds).

A.2 Choice of the bending radius

The bending radius of the products depends on the practical conditions of fabrication, and it is difficult to give a specific minimum bending radius to be respected. However, under normal conditions of use, a bending radius can be provided in accordance with Table A.1.

Table A.1 — Minimum inside bend radii for normal conditions of use

Grade	Minimum inside bend radii for bend angle 180° mm [a, b]
FeE 315	0 t
FeE 355	0,5 t
FeE 420	0,5 t
FeE 460	1,0 t
FeE 500	1,0 t
FeE 550	1,5 t
FeE 600	1,5 t
FeE 650	2,0 t
FeE 700	2,0 t
[a] The values apply to transverse test pieces.	
[b] t = thickness, in millimeters, of the test piece for bend test.	

Attention is drawn to the fact that these values may, under certain conditions, be:

— increased if the products are subjected to certain descaling processes (e.g. shot-blasting);

— reduced or increased to take into consideration the practical conditions of use (length of the folds, preparation, etc.).

EXAMPLE For verification of the material's properties under normal folding conditions where no lateral contraction occurs, the minimum values of the mandrel diameter provided in Table A.1 should be increased as mentioned in Table A.2.

A.3 Test unit

One bend test shall be carried out by test unit defined in 6.2.

Table A.2 — Minimum inside bend radii for cold forming

Grade	Minimum recommended inside bend radii for nominal thickness t mm[a]	
	$4 \leqslant t \leqslant 6$	$t > 6$
FeE 315	0,5 t	1,0 t
FeE 355	0,5 t	1,0 t
FeE 420	1,0 t	1,5 t
FeE 460	1,0 t	1,5 t
FeE 500	1,5 t	2,0 t
FeE 550	1,5 t	2,0 t
FeE 600	1,5 t	2,0 t
FeE 650	2,0 t	2,5 t
FeE 700	2,0 t	2,5 t

[a] The values are applicable for bend angles $\leqslant 90°$.

A.4 Test piece

The test piece shall be of rectangular cross-section with a width $\geqslant$ 30 mm, and a thickness equal to that of the product. The axis of the test piece shall be transverse to the direction of rolling.

A.5 Test method and interpretation

The test shall be carried out in accordance with ISO 7438. Any small cracks on the edges of the test pieces, for the detection of which magnification is necessary, shall not be taken into consideration.

Bibliography

[1] ISO 630:1995, *Structural steels — Plates, wide flats, bars, sections and profiles*.

[2] ISO 4950-1:1995, *High yield strength flat steel products — Part 1: General requirements*.

[3] ISO 4950-2:1995, *High yield strength flat steel products — Part 2: Products supplied in the normalized or controlled rolled condition*.

[4] ISO 4950-3:1995, *High yield strength flat steel products — Part 3: Products supplied in the heat-treated (quenched + tempered) condition*.

[5] ISO 5951:—[1)], *Hot-rolled steel sheet of higher yield strength with improved formability*.

1) To be published. (Revision of ISO 5951:1993)

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