International Standard 4952

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Structural steels with improved atmospheric corrosion resistance

Aciers de construction à résistance améliorée à la corrosion atmosphérique

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4952 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in January 1980.

It has been approved by the member bodies of the following countries :

Australia	Germany, F. R.	Poland
Austria	Hungary	Romania
Bulgaria	India	South Africa, Rep. of
Canada	Italy	Spain
Chile	Japan	Sweden
China	Korea, Dem. P. Rep. of	Switzerland
Czechoslovakia	Korea, Rep. of	United Kingdom
Denmark	Netherlands	USSR
Egypt, Arab Rep. of	New Zealand	
France	Norway	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Belgium
USA

Printed in Switzerland

Structural steels with improved atmospheric corrosion resistance

1 Scope

This International Standard specifies the chemical and mechanical properties, methods of manufacture, acceptance conditions and marking of structural steel products with improved atmospheric corrosion resistance.

2 Field of application

This International Standard applies to plates hot-rolled on reversing mills having a thickness of 3 mm and over, wide flats, bars, beams, sections and hollow sections[1] generally used in the delivery condition and which, as a rule, form part of the bolted, riveted or welded structures in metal constructions[2] and which have an improved atmospheric corrosion resistance.

It does not deal with steels for which other International Standards exist, in particular

— General purpose structural steels (ISO 630);

— Steels for boilers and pressure purposes (cf ISO 2604/4);

— Steels for heat treatment;

— High yield strength steels (ISO 4950);

— Continuously hot-rolled structural steel sheet with improved atmospheric corrosion resistance (ISO 5952);

— Steel plates for forming and deep drawing[3].

The position and orientation of samples are given in the annex.

3 References

ISO 82, *Steel — Tensile testing.*

ISO/R 148, *Beam impact test (V-notch) for steel.*

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

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

ISO 630, *Structural steels.*

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 4950, *High yield strength flat steel products —*
Part 1 : General requirements.
Part 2 : Products supplied in the normalized or controlled rolled condition.
Part 3 : Products supplied in the heat-treated (quenched and tempered) condition.

4 Definition

steel with improved atmospheric corrosion resistance : A steel in which a certain number of alloying elements, such as P, Cu, Cr, Ni, Mo,... have intentionally been added in order to increase its resistance to atmospheric corrosion, by forming an auto-protective oxide layer for the base metal.

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

2) For precautions to be taken in welding, see in particular the guide for welding and weldability of C-Mn and C-Mn micro-alloy steels, published by Sub-Commission IX-G of the International Welding Institute (document IIS/IIW 382-71).

3) An International Standard dealing with plates for forming and deep drawing is in preparation.

5 Manufacture

5.1 Steel manufacturing process

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

5.2 Deoxidation process

With the exception of qualities 1 A, B and 2 B, the steels shall be from casts with the addition of elements capable of producing a fine grain.

Steel of quality 1 A, B and 2 B shall be supplied as non-rimming steel.

5.3 Delivery condition

The products are usually delivered in accordance with the directions in the table below :

Quality	Flat products		Long products	
	As rolled	Normalized[1)]	As rolled	Normalized[1)]
1 A	x		x	
B, 2 B	x	(x)	x	
C, 2 C	x	(x)	x	(x)
D, 1 D, 2 D		x	x	x

1) Normalized or equivalent condition obtained by controlled rolling.

x) Signifies that the products concerned may be supplied in the normalized or equivalent condition in order to obtain the required properties.

5.4 Surface appearance — Defects

5.4.1 Surface appearance

The products shall have a smooth surface corresponding to the rolling procedure used; they shall not show any defects which may be prejudicial to their use or their careful application.

5.4.2 Removal of defects

5.4.2.1 Small defects may be removed by grinding, by the manufacturer, provided that the thickness locally is not reduced by more than 7 % (and 3 mm at the most) in relation to its nominal value and that it remains within the thickness tolerances.

5.4.2.2 Unless specified to the contrary in the order, defects which are larger than those stipulated above may be removed and built up by welding within the following conditions :

5.4.2.2.1 Removal of surface defects

a) The total area of the ground or chiselled surface of the product shall not, before welding, exceed 2 % of the total surface of the product.

b) The thickness of the material taken off in order to remove the defect shall not, before welding, exceed 20 % of the nominal thickness at the location of the defect and the depth of the pit before welding shall, under no circumstances, exceed 30 mm.

c) Defects in the toes (flanges) of angles, beams, U bars and Z bars and also the stems (webs) and toes (flanges) of T sections may be repaired by chiselling, grinding or gouging with a blow-lamp and welding. The depth of the pit, before welding, measured from the toe (flange) inwards, is limited to the thickness of the product at the base of this pit with a maximum of 13 mm.

d) Defects in the edges of the plates may be repaired by the manufacturer by chiselling, grinding or gouging with a blow-lamp and welding. The depth of the pit before welding, measured from the edge inwards, is limited to the thickness of the plate with a maximum of 25 mm.

e) Reduction of the cross-section of round, square or hexagonal bars, or reduction in the thickness of flat bars, due to the removal of a defect before welding, shall not exceed 5 % of the nominal dimension of the cross-section or of the thickness at the location of the defect.

f) The depth of the pit caused by removing a defect on the edge of flat bars, before welding, shall be measured from the edge inwards and shall be limited to the lower of the two following values : the thickness of the flat bar or 13 mm.

5.4.2.2.2 Repair by welding

a) All welding operations shall be carried out by qualified welders using low hydrogen electrodes appropriate to the grade of the item being repaired. The electrodes shall be protected from moisture during storage and use.

b) The manufacturer shall lay down and follow detailed welding methods corresponding to the material to be welded.

5.4.2.3 Repair quality

The welds and heat affected zone shall be sound and free from cracks; the metal deposited shall be completely melted and spread over the whole surface and edges without pits or overlap. Visible cracks, porosity, lack of penetration or pits discovered in one bead shall be removed before a following bead is deposited. After the surfacing operation, the deposited metal shall come at least 2 mm above the rolling surface and shall then be flattened by grinding or chiselling or both, in order to give a technically smooth and level surface.

5.4.2.4 Inspection of repair

The manufacturer shall draw up an inspection programme to verify that

a) the defects have been completely removed;

b) the limitations specified above have been respected;

c) the welding methods laid down have been followed;

d) the weld deposits are of the minimum quality indicated above.

5.4.2.5 Subsequent treatments

If the repair welding has been carried out on a product which has already been normalized, another normalizing process is always necessary. It is not necessary to re-test after this treatment. For flat products, if the repair welding has been carried out on as-rolled product, a stress relieving or normalizing treatment may be desirable.

6 Characteristics of grades and qualities

6.1 Chemical composition

6.1.1 Ladle analysis

The ladle analysis shall be in accordance with the limits specified in table 1.

6.1.2 Product analysis

This analysis may be required by the purchaser; in this case it shall be specified when ordering. Table 2 gives the limits of permissible deviations in the product analysis in relation to the limits for the ladle analysis in table 1 for the elements requested by the purchaser.

Only elements added intentionally form the subject of an analysis.

6.2 Mechanical properties

Table 3 gives the mechanical properties guaranteed in the delivery conditions defined in 5.3 and determined on test pieces selected in accordance with the specifications of clause 7.

For products more than 70 mm thick, the mechanical properties shall form the subject of an agreement when ordering.

NOTE — In the case of sections and beams, thickness of the product means the thickness of the flange to the right of the position of sampling test pieces for mechanical tests (see the figure in the annex). However, if following an agreement, samples are taken from the web, the thickness of the product is the thickness of the web to the right of the sample.

7 Acceptance conditions

7.1 The rolled products covered by this International Standard may be the subject of an acceptance test under the conditions specified in clause 5 of ISO/R 404 which relates to the mechanical and chemical properties of the product. Verification of the chemical composition of the product is only made if agreed when ordering.

7.2 If acceptance testing has been specified when ordering, batching is carried out by cast for all grades and qualities.

7.3 Series of tests

7.3.1 One set of tests is carried out for every 50 t or part thereof for products of the same form from the same cast and in the same thickness range as defined in table 3.

However, if agreed when ordering, the acceptance unit may consist of the parent plate.

Table 1 — Chemical composition

Grade	Quality	C % max.	Mn %	Si %	P %	S % max.	Cr %	Cu %	Ni % max.	Mo % max.	Zr % max.
Fe 235 W	B	0,13	0,20 to 0,60	0,10 to 0,40	≤ 0,040	0,035	0,40 to 0,80	0,20 to 0,50	0,65		
	C[1)]	0,13	0,20 to 0,60	0,10 to 0,40	≤ 0,040	0,035	0,40 to 0,80	0,20 to 0,50	0,65		
	D[1)]	0,13	0,20 to 0,60	0,10 to 0,40	≤ 0,040	0,035	0,40 to 0,80	0,20 to 0,50	0,65		
Fe 355 W	1 A	0,12	≤ 1,00	0,20 to 0,75	0,06 to 0,15	0,050	0,30 to 1,25	0,25 to 0,55	0,65		
	1 D[1)]	0,12	≤ 1,00	0,20 to 0,75	0,06 to 0,15	0,050	0,30 to 1,25	0,25 to 0,55	0,65		
	2 B	0,19	0,50 to 1,50	≤ 0,50	≤ 0,040	0,050	0,40 to 0,80	0,20 to 0,55	0,65	0,30	0,15
	2 C[1)]	0,19	0,50 to 1,50	≤ 0,50	≤ 0,040	0,050	0,40 to 0,80	0,20 to 0,55	0,65	0,30	0,15
	2 D[1)]	0,19	0,50 to 1,50	≤ 0,50	≤ 0,040	0,050	0,40 to 0,80	0,20 to 0,55	0,65	0,30	0,15

1) These steels shall contain at least one of the following grain-refining elements in the proportions indicated below :

Total Al ≥ 0,015 %

Nb = 0,015 to 0,060 %

V = 0,02 to 0,15 %

Ti = 0,02 to 0,10 %.

If these elements are used in combination, at least one of them shall be present in the steel in the minimum specified quantity.

Table 2 — Maximum deviations for product analysis relative to the specified ladle analysis[1)]

Elements	Specified limits	Permissible deviation
C	⩽ 0,19	+ 0,03
Mn	⩾ 0,20 ⩽ 1,50	+ 0,10 − 0,05
Si	⩾ 0,10 ⩽ 0,75	+ 0,10 − 0,05
P	⩽ 0,040	+ 0,005
	⩾ 0,06 ⩽ 0,15	± 0,01
S	⩽ 0,050	+ 0,005
Cr	⩾ 0,30 ⩽ 0,80	± 0,05
	> 0,80 ⩽ 1,25	± 0,10
Ni	⩽ 0,65	+ 0,05
Mo	⩽ 0,30	+ 0,05
Cu	⩾ 0,20 ⩽ 0,55	± 0,05
Zr	⩽ 0,15	+ 0,02
Nb	⩾ 0,015 ⩽ 0,060	± 0,005
V	⩾ 0,02 ⩽ 0,15	− 0,01 + 0,02
Ti	⩾ 0,02 ⩽ 0,10	− 0,01 + 0,02

1) The deviations apply either above or below the specified limit of the range, but not simultaneously for one element from different samples taken from different products originating from the same cast.

When maxima only are specified, the deviations are positive only. The values only apply to samples prepared under the conditions laid down in 7.5.5.2.

Table 3 — Mechanical properties

Grade	Quality	Specified yield strength N/mm², min.				R N/mm² min.	A % min. on $5{,}65\sqrt{S_o}$ [1) 4)]	KV J min.[2)]		
								+ 20 °C	0 °C	− 20 °C
		$e \leqslant 16$	$16 < e \leqslant 40$	$40 < e \leqslant 63$						
Fe 235 W	B	235	225	215		360	25	27		
	C	235	225	215		360	25		27	
	D	235	225	215		360	25			27
		$e \leqslant 16$	$16 < e \leqslant 35$	$35 < e \leqslant 50$	$50 < e \leqslant 70$					
Fe 355 W	1 A	355[3)]				480	20			
	1 D	355[3)]				480	20			27
	2 B	355	345	335	325	470	20	27		
	2 C	355	345	335	325	470	20		27	
	2 D	355	345	335	325	470	22			27

1) For transverse test pieces (plates and wide flats not less than 600 mm wide), these values are reduced by 2 points.

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

3) This quality is only delivered as a product not more than 12 mm thick.

4) Non-proportional test pieces may also be used (see 7.5.1).

7.3.2 The set of tests comprises :

— one tensile test (or more, in accordance with 7.3.4.1 for products not more than 16 mm thick);

— one series of three impact strength tests at + 20 °C for quality B, at 0 °C for quality C and at − 20 °C for quality D,

and, if specified when ordering,

— one product analysis (see 6.1.2).

7.3.3 If provided for when ordering, the purchaser or his agent may select the pieces from which samples will be taken for checking the properties.

7.3.4 In the absence of any indication by the purchaser, the procedure will be as follows :

7.3.4.1 Tensile test

A sample is taken from the thickest product per thickness group — with, however, the additional condition for group $e \leqslant 16$ mm that the maximum thickness of the products in the batch is no more than twice the minimum thickness.

7.3.4.2 Impact strength test

A sample is taken from the thickest product per thickness group.

For quality D, if agreed when ordering, a sample may be taken from each piece.

7.4 Location and orientation of test pieces (see ISO/R 377)

7.4.1 Plates and wide flats of width equal to or greater than 600 mm

7.4.1.1 Sampling shall be carried out so that the axis of the test piece is mid-way between the axis of rolling and the edge of the rolled product.

7.4.1.2 The axis of tensile test pieces shall be perpendicular to the direction of rolling. In the case of cylindrical test pieces, the axis of the test piece lies at 1/6 of the thickness of the product.

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

7.4.2 Wide flats less than 600 mm wide

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

7.4.3 Sections and beams

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

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

The choice of sample positions is at the option of the manufacturer; however, in cases of dispute, only the results obtained from test pieces taken from the flange shall be considered.

7.4.4 Rounds, squares, flats, hexagons and other similar products

The longitudinal axis of the test pieces is parallel to the direction of rolling.

For small sizes, the test piece consists of a section of the product.

In the other cases, sampling is carried out so that the axis of the test piece is located as far as possible :

— for a prismatic test piece, at 1/3 of the half-width or the half-diagonal;

— for a cylindrical test piece, in the outer 1/3 of the half-diameter (see the figure in the annex).

7.4.5 Hollow sections

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

For circular sections, the test piece shall be taken longitudinally at any point on 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 from outside the weld zone.

7.5 Methods of test — Types of test pieces

7.5.1 Tensile test (see ISO 82)

7.5.1.1 The test piece used is generally a proportional prismatic or cylindrical test piece having an original gauge length given by the formula

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

where S_o is the cross-section of the calibrated part of the test piece.

The prismatic test piece of rectangular cross-section has a maximum calibrated width of 40 mm, and its thickness is 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 one face.

The cylindrical test piece has a diameter of 10 to 30 mm, the original gauge length being determined in accordance with the above formula.

7.5.1.2 A non-proportional test piece with a constant initial gauge length may also be used. In this case

a) if the gauge length is 200 mm

— for flat products, the guaranteed elongation value is A % ⩾ 16;

— for bars, beams and sections, the guaranteed elongation value is A % ⩾ 18 for products more than 8 mm thick and A % ⩾ 16 for products not more than 8 mm thick;

b) for other gauge lengths, reference must be made to a conversion table (see ISO 2566/1).

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

7.5.1.3 The yield strength specified in the tables is the upper yield strength or the yield strength at 0,5 % (total elongation).

If, by agreement when ordering, a conventional yield strength at 0,2 % (non-proportional elongation) or the lower yield strength or the yield strength R_{tx} is required, this specification is satisfied if the value obtained for a measurement of this kind attains the yield strength values specified in the table.

7.5.2 Impact strength test

7.5.2.1 The impact strength test is normally carried out on products not less than 12 mm thick or not less than 16 mm in diameter. The test piece is machined in such a way that the surface nearest the rolling skin is not more than 2 mm from it; the notch is perpendicular to the rolling skin.

If agreed when ordering, impact strength tests may be carried out on products less than 12 mm thick, the dimensions of the test pieces shall comply with the specifications in ISO/R 148, i.e. 10 mm × 7,5 mm and 10 mm × 5 mm, and the energy values to be guaranteed shall be fixed by common agreement. However, if agreed when ordering, the test pieces may have a width equal to the thickness of the product provided that this is not less than 5 mm.

7.5.2.2 This test is carried out using a V-notch beam test piece (see ISO/R 148), the value to be taken into consideration is the arithmetical average of the results obtained from three adjacent test pieces in the same piece, unless a supplementary test is necessary (see 7.5.4).

7.5.3 Defective tests or test pieces

7.5.3.1 When a test does not give the prescribed results because of an error in performing the test, it shall be annulled. An error in performing the test means defective machining, incorrect mounting in the test machine, a malfunction of this machine, or any other anomaly independent of the metal itself.

7.5.3.2 If a test piece having a defect gives satisfactory results, the batch is accepted, but the piece in question may be subjected to a special examination for soundness.

7.5.4 Supplementary tests

If, during an acceptance test, a test fails to give the results required, unless otherwise agreed, it leads to supplementary tests as stated below :

7.5.4.1 Tensile tests

7.5.4.1.1 If the test piece does not satisfy the requirements, the piece in question is considered not to conform to the product specification, unless two other test pieces from the same piece have been tested and have given satisfactory results. In this case, the piece and the batch are considered to conform with the product specification.

7.5.4.1.2 If one or both supplementary test pieces do not satisfy the requirements, the piece in question is considered not to conform to the specification.

In this case, the requirements of clause 8 may be applied.

7.5.4.2 Impact strength test

7.5.4.2.1 If the average of the three impact strength values is less than the specified minimum average value or if one individual value is less than 70 % of this specified value, three supplementary test pieces are taken from the same sample and subjected to a test. The average value of the six results shall not be less than the specified minimum average value. Not more than two of the individual values shall be lower than the specified minimum average value and only one individual value may be less than 70 % of this value.

7.5.4.2.2 If the piece put forward for the first time is considered not to conform to the product specification, the remaining material may be accepted, provided that two representative pieces have been subjected to tests in accordance with the requirements and have given satisfactory results.

Otherwise, the requirements of clause 8 may be applied.

7.5.5 Chemical analysis

7.5.5.1 In cases of dispute the method used for the chemical analysis shall be in accordance with the specifications of the corresponding ISO publications. If no ISO publication exists, the method to be used shall be the subject of agreement between the interested parties.

7.5.5.2 If a product inspection analysis is provided for when ordering, the number of samples to be taken shall be the subject of agreement between the parties. The analysis is carried out only for those added intentionally.

The samples may be taken from the test pieces removed to check the mechanical properties, or from the full thickness of the product at the same location as the test pieces.

In cases of dispute, only the analysis of the chips obtained from the full thickness of the product is to be taken into consideration.

For the selection and preparation of samples for chemical analysis, the requirements of 3.2 and 3.3 of ISO/R 377 must be applied.

7.6 Documents

The recommendations of 5.2 and 5.3 in ISO 404 shall be complied with. The type of certificate required shall be specified when ordering.

8 Re-testing (see 6.5 in ISO 404)

8.1 The manufacturer may, if necessary, resubmit for acceptance the pieces rejected during the first examination because of unsatisfactory properties after subjecting them to a suitable treatment (re-grading, heat treatment) which will be indicated to the purchaser on request. In this case, the tests are carried out as if they applied to a new acceptance unit.

8.2 The manufacturer reserves the right to present in a different quality or grade the pieces rejected at the first examination.

9 Non-destructive tests

If the purchaser requires non-destructive tests to verify the soundness of the products by means of radiographic, ultrasonic, magnetic or dye penetrant methods, these tests shall be agreed when the tender and order are made. This agreement shall include details of the method of test and the interpretation of the results.

10 Marking

Unless otherwise agreed when ordering, the products shall bear the following marks :

a) a symbol identifying the quality and grade of the steel;

b) the cast number;

c) the initials of the supplier;

and possibly,

d) a symbol, letters or numbers allowing the certificates, samples and products to be identified.

In the case of products of small unit mass conditioned in tied bundles, marking may simply consist of a label attached to each bundle or to the top product in the bundle.