INTERNATIONAL STANDARD

ISO 4955

Third edition
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Heat-resistant steels

Aciers réfractaires

Reference number
ISO 4955:2005(E)

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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 4955 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 4, *Heat treatable and alloy steels*.

This third edition cancels and replaces the second edition (ISO 4955:1994), which has been technically revised.

Heat-resistant steels

1 Scope

1.1 This International Standard specifies requirements for the grades of wrought steels, listed in Table 1, which are usually employed for products for which the resistance to the effects of hot gases and the products of combustion at temperatures in the region above 550 °C is the main requirement.

1.2 This International Standard is applicable to

— flat products;

— bars;

— sections;

— wire and rod;

— forgings.

NOTE 1 Heat-resisting steels for valves are covered by ISO 683-15.

NOTE 2 Corrosion-resistant stainless steels for which resistance to corrosion is of primary importance are covered by ISO 16143-1, ISO 16143-2 and ISO 16143-3.

NOTE 3 Not all of the steels included in this International Standard are necessarily available in all product forms.

NOTE 4 Wire in the cold-worked condition is covered by ISO 16143-3.

1.3 In addition to this International Standard, the general technical delivery requirements of ISO 404 are applicable.

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 377:1997 + Cor.1:1997, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing (including Technical Corrigendum 1:1997)*

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

ISO 4885:1996, *Ferrous products — Heat treatments — Vocabulary*

ISO/TS 4949:2003, *Steel names based on letter symbols*

ISO 6506-1:1999, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6892:1998, *Metallic materials — Tensile testing at ambient temperature*

ISO 6929:1987, *Steel products — Definitions and classification*

ISO/TR 9769:1991, *Steel and iron — Review of available methods of analysis*

ISO 10474:1991, *Steel and steel products — Inspection documents*

ISO 14284:1996, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 377, ISO 404, ISO 4885, ISO 6929, ISO 14284 and the following apply.

3.1
heat-resisting steels
steels used at above 550 °C (wustite point) due to their excellent resistance to the effects of hot gases and products of combustion, as well as their resistance to the influence of molten salts and molten metals, but also showing good mechanical properties during short- and long-term stressing.

4 Designation

The steel names given in the relevant tables were allocated in accordance with ISO/TS 4949.

5 Information to be supplied by the purchaser

It shall be the responsibility of the purchaser to specify all requirements that are necessary for products under this specification. Such requirements to be considered include, in the order listed, but not limited to, the following:

— the desired quantity;

— the product form;

— the number of the appropriate dimensional standard (see Annex A), the nominal dimensions, plus any choice of requirements;

— the type of material (steel);

— the number of this International Standard (ISO 4955);

— the steel name;

— the desired process route, including surface finish (see 7.2, 7.5 and footnote d to Table 3);

— if an inspection document is required, its designation according to ISO 10474.

EXAMPLE 1 ton of plates according to ISO 9444 with a specified thickness of 5,0 mm, a specified width of 1 200 mm, with trimmed edges (T) and a specified length of 2 500 mm, made of a steel grade with the name X8NiCrAlTi32-21 as specified in ISO 4955, in process route 1U and inspection certificate 3.1B as specified in ISO 10474:

1 t plate ISO 9444 — 5,0 x 1200T x 2500
Steel ISO 4955 — X8NiCrAlTi32-21 + 1U
ISO 10474 - 3.1.B

6 Classification of grades

Heat-resisting steels covered in this International Standard are classified according to their structure into:

— ferritic steels;

— austenitic steels.

7 Requirements

7.1 Manufacturing process

Unless a special steelmaking process is agreed when ordering, the steelmaking process shall be at the discretion of the manufacturer. When he so requests, the purchaser shall be informed what steelmaking process is being used.

7.2 Delivery condition

The products shall be supplied in the delivery condition agreed in the order, by reference to the process route given in Tables 3 and 4 (see also Annex B).

7.3 Chemical composition

7.3.1 The chemical composition requirements given in Table 1 apply with respect to the chemical composition of the cast analysis.

7.3.2 The product analysis may deviate from the limiting values for the cast analysis given in Table 1 by the values listed in Table 2.

7.4 Mechanical properties

The mechanical properties at room temperature, as specified in Tables 5 and 6, apply for the relevant heat-treatment condition. This does not apply to the process route 1U and 3U (hot rolled, not heat treated, not descaled). If, by agreement at the time of ordering, the products are to be supplied in a non-heat-treated condition, the mechanical properties specified in Tables 5 and 6 shall be obtainable from reference test pieces which have received the appropriate heat treatment (simulated heat treatment).

7.5 Surface quality

Availability, and the determination of the types of process route and surface finish most suited to a particular case, should be discussed with the manufacturer.

The general surface appearance, with respect to soundness and surface finish, shall be consistent with good production practice, for the grade and quality ordered, as determined by visual inspection. When products are delivered in coil form, the degree and extent of imperfections may be expected to be higher, due to the impracticability of removing short lengths of coil.

Except for symbols 1G, 3G, 4G, 3P and 4P, minor surface imperfections caused by the manufacturing process are no cause for rejection.

If more exact requirements for the surface quality are necessary, this shall be agreed at the time of enquiry and order.

7.6 Internal soundness

For the internal soundness, where appropriate, requirements together with the conditions for their verification may be agreed at the time of enquiry and order.

7.7 Dimensions and tolerances on dimensions and shape

7.7.1 The dimensions and tolerances on dimensions and shape are to be agreed at the time of enquiry and order, as far as possible with reference to the International Standards for dimensions listed in Annex A. The ordered dimensions shall, where applicable, include the minimum machining allowances.

7.7.2 If none of the International Standards listed in Annex A is applicable, then the dimensions and tolerances should be agreed at the time of enquiry and order on the basis of regional or national standards.

8 Inspection, testing and conformance of products

8.1 General

The manufacturer shall carry out appropriate process control, inspection and testing to assure himself that the delivery complies with the requirements of the order.

This includes the following:

— a suitable frequency of verification of the dimensions of the products;

— an adequate intensity of visual examination of the surface quality of the products;

— an appropriate frequency and type of test to ensure that the correct grade of steel is delivered.

The nature and frequency of these verifications, examinations and tests are determined by the manufacturer, based on the degree of consistency that has been determined by the evidence of his quality system. In view of this, verifications by specific tests for these requirements are not necessary, unless otherwise agreed.

8.2 Inspection procedures and types of inspection documents

8.2.1 For each delivery, the issue of any inspection document according to ISO 10474 may be agreed upon at the time of enquiry and order.

8.2.2 If, in accordance with the agreements made at the time of enquiry and order, a test report is to be provided, this shall cover:

a) the statement that the material complies with the requirements of the order;

b) the results of the cast analysis for all elements specified for the type of steel supplied.

8.2.3 If, in accordance with the agreements in the order, an inspection certificate 3.1.A, 3.1.B or 3.1.C or an inspection report 3.2 (see ISO 10474) is to be provided, the specific inspections and tests described in 8.3 shall be carried out and their results shall be certified in the document.

In addition to 8.2.2, the document shall cover

a) the results of the mandatory tests marked in the second column of Tables 7 and 8 by an "m";

b) the results of any optional test or inspection agreed when ordering.

8.3 Specific inspection and testing

8.3.1 Extent of testing

The tests to be mandatorily (m) carried out, the composition and size of the test units, and the number of sample products, samples and test pieces to be taken are given in Tables 7 and 8.

8.3.2 Selection and preparation of samples and test pieces

8.3.2.1 The general conditions for selection and preparation of samples and test pieces shall be in accordance with ISO 377 and ISO 14284.

8.3.2.2 The samples for the tensile test shall be taken in accordance with Figures 1 to 3. Samples from flat products shall be taken in such a way that they are located halfway between the centre and a longitudinal edge.

The samples shall be taken from products in the delivery condition. If agreed, the samples may be taken from flat products before flattening, or from bars before straightening.

For samples to be given a simulated heat treatment, the conditions for annealing shall be agreed.

8.3.2.3 Samples for the hardness test, where requested, shall be taken from the same locations as those for the tensile test.

8.4 Test methods

8.4.1 Unless otherwise agreed when ordering, the choice of a suitable physical or chemical method of analysis to determine the product analysis is at the discretion of the manufacturer. In cases of dispute, the analysis shall be carried out by a laboratory approved by the two parties. In these cases, the reference method of analysis shall be agreed, where possible, with reference to ISO/TR 9769.

8.4.2 The tensile test at room temperature shall be carried out in accordance with ISO 6892, taking into account, for flat products, the additional or deviating conditions specified in footnote a of Figure 3.

Unless otherwise agreed, $R_{p0,2}$, R_m and A shall be determined. For austenitic steels, $R_{p1,0}$ may be reported instead of $R_{p0,2}$, if agreed between purchaser and manufacturer.

8.4.3 The Brinell hardness test shall be carried out in accordance with ISO 6506-1.

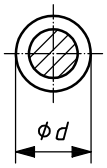
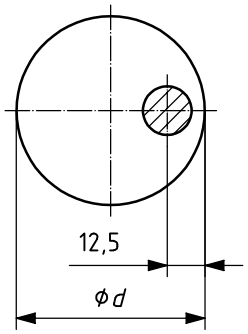
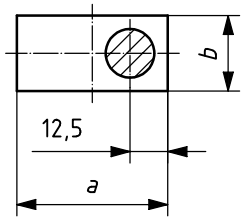
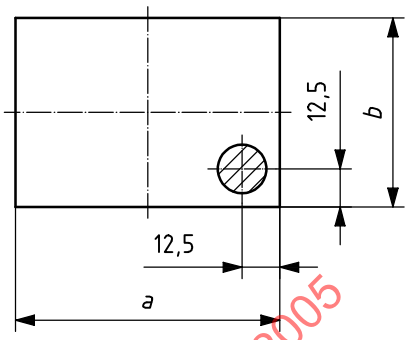
8.4.4 Dimensions and dimensional tolerances of the products shall be tested in accordance with the requirements of the relevant International Standards for dimensions given in Annex A.

8.5 Retest

See ISO 404.

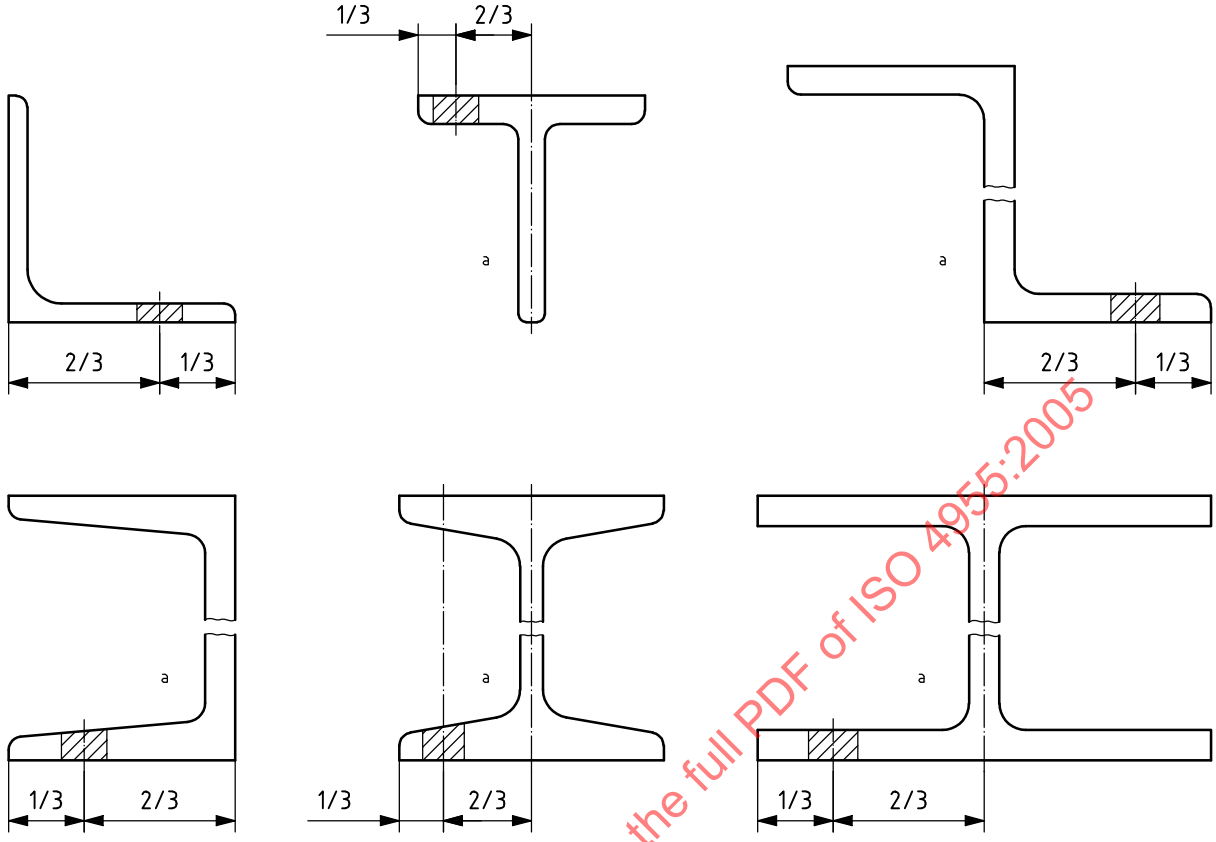
9 Marking

The products shall be marked with the manufacturer's symbol, the steel grade, and, if so agreed when ordering, with the cast number. When specific inspection is carried out, the products shall be provided additionally with an identification number, which enables the test pieces to be related to the cast and product from which they stem.

Type of test	Round cross-section products mm		Rectangular cross-section products mm	
Tensile				
	$d \leqslant 25$[a]	$25 < d \leqslant 160$	$b \leqslant 25$ $a \geqslant b$	$25 < b \leqslant 160$ $a \geqslant b$

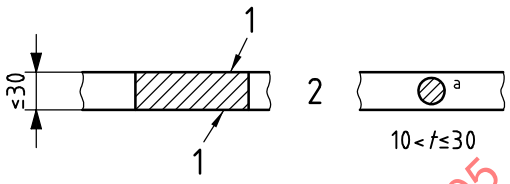
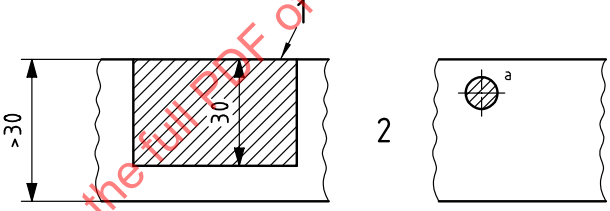
[a] Samples of product may alternatively be tested unmachined.

Figure 1 — Location of test pieces for steel bars, rods and wire of diameter or thickness ≤ 160 mm (longitudinal test pieces)



a By agreement, the sample can be taken from the web, at a quarter of the total height.

Figure 2 — Location of test pieces for beams, channels, angles, T-sections and Z-sections

Type of test piece	Product thickness	Direction of the longitudinal axis of the test piece in relation to the principal direction of rolling at a product width of:		Distance of the test piece from the rolled surface
	mm	< 300 mm	⩾ 300 mm	mm
Tensile[a]	⩽ 30	Longitudinal	Transverse	 **Key** 1 rolled surface 2 flat or round test piece may be used
	> 30			 **Key** 1 rolled surface 2 flat or round test piece may be used

[a] In cases of doubt or dispute, the gauge length shall be $L_o = 5{,}65\sqrt{S_o}$ for test pieces from products ⩾ 3 mm.

For products < 3 mm in thickness, non-proportional test pieces with a gauge length of 80 mm and a width of 20 mm shall be used, but test pieces with a gauge length of 50 mm and a width of 12,5 mm may also be applied. For products with a thickness of 3 mm to 10 mm, flat proportional test pieces with two rolled surfaces and a maximum width of 30 mm shall be used. For products with thickness > 10 mm, one of the following proportional test pieces may be used:

— either a flat test piece with a maximum thickness of 30 mm; the thickness may be reduced to 10 mm by machining, but one rolled surface must be preserved;

— or a round test piece with a diameter of ⩾ 5 mm the axis of which shall be located as near as possible to a plane in the outer third of half the product thickness.

Figure 3 — Location of test pieces in sheet, strip or plate

Table 1 — Types of steel and chemical composition (applicable to cast analysis)

Type of steel designation[a]			Chemical composition (mass fraction)								
No.	Name	According to ISO 4955:1994	C	Si	Mn max.	P max.	S max.	N	Cr	Ni	Others
Ferritic steels											
1	X2CrTi12	(1)	⩽ 0,03	⩽ 1,00	1,00	0,040	0,015	—	10,5 to 12,5	—	Ti: 6×(C+N) to 0,65
2	X6Cr13	2	⩽ 0,08	⩽ 1,00	1,00	0,040	0,030	—	12,0 to 14,0	⩽ 1,00	—
3	X10CrAlSi13	3	⩽ 0,12	0,70 to 1,40	1,00	0,040	0,015	—	12,0 to 14,0	⩽ 1,00	Al: 0,70 to 1,20
4	X6Cr17	4	⩽ 0,08	⩽ 1,00	1,00	0,040	0,030	—	16,0 to 18,0	⩽ 1,00	—
5	X10CrAlSi18	5	⩽ 0,12	0,70 to 1,40	1,00	0,040	0,015	—	17,0 to 19,0	⩽ 1,00	Al: 0,70 to 1,20
6	X10CrAlSi25	6	⩽ 0,12	0,70 to 1,40	1,00	0,040	0,015	—	23,0 to 26,0	⩽ 1,00	Al: 1,20 to 1,70
7	X15CrN26	7	⩽ 0,20	⩽ 1,00	1,00	0,040	0,030	0,15 to 0,25	24,0 to 28,0	⩽ 1,00	—
8	X2CrTiNb18	—	⩽ 0,03	⩽ 1,00	1,00	0,040	0,015	—	17,5 to 18,5	—	Ti: 0,10 to 0,60 Nb: (3×C+0,30) to 1,00[c]
9	X3CrTi17	—	⩽ 0,05	⩽ 1,00	1,00	0,040	0,015	—	16,0 to 18,0	—	Ti: [4×(C+N)+0,15] to 0,80[b]
Austenitic steels											
10	X7CrNi18-9	10	0,04 to 0,10	⩽ 1,00	2,00	0,045	0,030	—	17,0 to 19,0	8,0 to 11,0	—
11	X7CrNiTi18-10	11	0,04 to 0,10	⩽ 1,00	2,00	0,045	0,030	—	17,0 to 19,0	9,0 to 12,0	Ti:5×C to 0,80
12	X7CrNiNb18-10	12	0,04 to 0,10	⩽ 1,00	2,00	0,045	0,030	—	17,0 to 19,0	9,0 to 12,0	Nb:10×C to 1,20 [c]
13	X15CrNiSi20-12	13	⩽ 0,20	1,50 to 2,50	2,00	0,045	0,030	⩽ 0,11	19,0 to 21,0	11,0 to 13,0	—
14	X7CrNiSiNCe21-11	14	0,05 to 0,10	1,40 to 2,00	0,80	0,040	0,030	0,14 to 0,20	20,0 to 22,0	10,0 to 12,0	Ce: 0,03 to 0,08
15	X12CrNi23-13	(15)	⩽ 0,15	⩽ 1,00	2,00	0,045	0,015	⩽ 0,11	22,0 to 24,0	12,0 to 14,0	—
16	X8CrNi25-21	(16)	⩽ 0,10	⩽ 1,50	2,00	0,045	0,015	⩽ 0,11	24,0 to 26,0	19,0 to 22,0	—
17	X8NiCrAlTi32-21	20	0,05 to 0,10	⩽ 1,00	1,50	0,015	0,015	—	19,0 to 23,0	30,0 to 34,0	Al: 0,15 to 0,60 Ti: 0,15 to 0,60 Cu: ⩽ 0,70
18	X6CrNiSiNCe19-10	—	0,04 to 0,08	1,00 to 2,00	1,00	0,045	0,015	0,12 to 0,20	18,0 to 20,0	9,0 to 11,0	Ce: 0,03 to 0,08
19	X6NiCrSiNCe35-25	—	0,04 to 0,08	1,20 to 2,00	2,00	0,040	0,015	0,12 to 0,20	24,0 to 26,0	34,0 to 36,0	Ce: 0,03 to 0,08

NOTE Elements not quoted in this table shall not be intentionally added to the steel without the agreement of the purchaser, other than for finishing the heat. All reasonable precautions should be taken to prevent the addition of such elements from scrap or other materials used in the manufacture, but residual elements may be present provided that the mechanical properties and applicability are not adversely affected.

a The designations given in the first column are consecutive numbers. The designations given in the second column are in accordance with ISO/TS 4949. The designations given in the third column represent the antiquated numbers of ISO 4955:1994.

b The stabilisation may be by use of titanium or niobium or zirconium. According to the atomic mass of these elements and the content of carbon and nitrogen, the equivalence shall be the following:

$$\text{Nb (mass fraction)} \triangleq \text{Zr (mass fraction)} \triangleq \frac{7}{4}\text{Ti (mass fraction)}.$$

c Tantalum determined as niobium.

Table 2 — Permissible deviation between the product analysis and the limiting values given in Table 1 for the cast analysis

Element	Cast analysis (specified limits) % (mass fraction)		Permissible deviations[a] from the specified composition % (mass fraction)
C		⩽ 0,20	± 0,01
Si		⩽ 1,00	± 0,05
	> 1,00	⩽ 2,50	± 0,10
Mn		⩽ 1,00	+ 0,03
	> 1,00	⩽ 2,00	+ 0,04
P		⩽ 0,040	+ 0,005
	> 0,040	⩽ 0,045	+ 0,010
S		⩽ 0,030	+ 0,005
N	> 0,03	⩽ 0,11	± 0,01
	> 0,11	⩽ 0,25	± 0,02
Cr	> 10,5	⩽ 15,0	± 0,15
	> 15,0	⩽ 20,0	± 0,20
	> 20,0	⩽ 28,0	± 0,25
Ni		⩽ 1,0	+ 0,03
	⩾ 8,0	⩽ 10,0	± 0,10
	> 10,0	⩽ 20,0	± 0,15
	> 20,0	⩽ 30,0	± 0,20
	> 30,0	⩽ 36,0	± 0,25
Al		⩽ 1,70	± 0,10
Ce		⩽ 0,08	± 0,01
Cu		⩽ 0,70	+ 0,04
Nb		⩽ 1,20	± 0,05
Ti		⩽ 1,00	± 0,03

[a] ± means that in one cast, and in more than one product analysis, the deviation may occur over the upper value or under the lower value of the specified range given in Table 1, but not both at the same time.

Table 3 — Type of process route and surface finish of heat-resisting flat steel products

	Type of process route	Surface finish	Symbol[a] Flat products	Remarks
Hot rolled	Hot rolled, not heat treated, not descaled	Covered with rolling scale	1U	Suitable for products to be further hot worked, e.g. strip for rerolling.
	Hot rolled, heat treated[b], not descaled	Covered with rolling scale	1C	Suitable for parts to be descaled or machined in subsequent production, or for certain heat-resisting applications.
	Hot rolled, heat treated, mechanically descaled	Free of scale	1E	The type of mechanical descaling, e.g. coarse grinding or shot blasting, depends on the steel grade and the product, and is left to the manufacturer's discretion, unless otherwise agreed.
	Hot rolled, heat treated, pickled	Free of scale	1D	Usual standard for most steel types to ensure good corrosion resistance; also common finish for further processing. It is permissible for grinding marks to be present. Not as smooth as 2D or 2B.
Cold rolled	Cold rolled, heat treated, not descaled	Smooth with scale from heat treatment.	2C	Suitable for parts to be descaled or machined in subsequent production or for certain heat-resisting applications.
	Cold rolled, heat treated, mechanically descaled	Rough and dull	2E	Usually applied to steels with a scale which is very resistant to pickling solution. May be followed by pickling.
	Cold rolled, heat treated, pickled	Smooth	2D	Finish for good ductility, but not as smooth as 2B or 2R.
	Cold rolled, heat treated, pickled, skin-passed	Smoother than finish 2D	2B	Most common finish for most steel types to ensure good corrosion resistance, smoothness and flatness. Also common finish for further processing. Skin passing may be by tension levelling.
	Cold rolled, bright annealed[b]	Smooth, bright, reflective	2R	Smoother and brighter than 2B. Also common finish for further processing.
Special finishes	Ground[c]	See footnote[d]	1G	Grade of grit or surface roughness can be specified. Unidirectional texture, not very reflective.

NOTE Not all process routes and surface finishes are available for all steels.

a First digit: 1 = hot rolled, 2 = cold rolled.

b May be skin passed.

c One surface only, unless specifically agreed at the time of enquiry and order.

d Within each finish description, the surface characteristics can vary, and more specific requirements may need to be agreed between the manufacturer and purchaser (e.g. grade of grit or surface roughness).

Table 4 — Type of process route and surface finish of heat-resisting long steel products

	Type of process route	Surface finish	Symbol[a] Flat products				Remarks
			Bars, sections	Rod	Wire	For-gings	
Hot formed	Hot formed, not heat treated, not descaled	Covered with scale, (spot ground if necessary)	3U	3U	—	—	3U: Suitable for products to be further hot formed. For semi-finished products, ground on all sides can be specified.
	Hot formed, heat treated[b], not descaled	Covered with scale, (spot ground if necessary)	3C	3C	—	5C	3C: Suitable for products to be further processed. For semi-finished products, ground on all sides can be specified.
	Hot formed, heat treated[b], mechanically descaled	Largely free of scale (but some black spots may remain)	3E	3E	—	5E	3E:The type of mechanical descaling, e.g. grinding , peeling or shot blasting, is left to the manufacturer's discretion, unless otherwise agreed. Suitable for products to be further processed.
	Hot formed, heat treated[b], pickled	Free of scale	3D	3D	—	5D	3D:Tolerance ⩾ IT 14[d, e].
	Hot formed, heat treated[b], rough machined (peeled or rough turned)	Metallically clean	3X	—	—	5X	3X: Tolerance ⩾ IT 12[d, e].
Cold processed	Heat treated[b], mechanically or chemically descaled, cold processed[c]	Smooth and bright. Substantially smoother than finishes 3E, 3D or 3X	4H	—	—	—	4H: On products formed by cold drawing without subsequent heat treatment, the tensile strength is substantially increased, particularly on austenitic structure, depending on the degree of forming. Tolerance IT 9 to IT 11[d, e].
	Cold processed, heat treated[b], pickled (skin-passed)	Smoother and brighter than finishes 3E or 3D	4D	—	4D	—	4D: Finish for good ductility (cold heading).
	Heat treated[b], machined (peeled), mechanically smoothed	Smoother and brighter than finishes 3D, 3E or 3X	4B	—	—	—	4B: Pre-finish for close ISO tolerances. Tolerance IT 9 to 11[d, e].
	Mechanically or chemically descaled, cold processed, bright annealed or bright annealed and slightly rerolled	Smoother and brighter than finishes 3D	—	—	4R	—	4R: Especially suitable for grinding, polishing and brushing.
Special finishes	Centreless ground	Uniform finish. Type and degree of grinding to be agreed	3G or 4G	—	—	—	3G or 4G: Surface roughness can be specified. Finish for close ISO tolerances. Normally obtained from material in finishes 3E, 3D, 4H or 4B. Tolerance ⩽ IT 8[d, e].
	Polished	Smoother and brighter than finish 3G or 4G. Type and degree of polishing to be agreed	3P or 4P	3P	4P	—	3P or 4P: Surface roughness can be specified. Finish for close ISO tolerances. Normally obtained from material in finishes 3E, 3D, 4G, 4H, 4B. Tolerance ⩽ IT 11[d, e].

NOTE Not all process routes and surface finishes are available for all steels.

a First digit: 3 = hot formed, 4 = cold processed, 5 = forged.

b On ferritic and austenitic grades, the heat treatment may be omitted if the conditions for hot forming and subsequent cooling are such that the requirements for the mechanical properties are obtained.

c The type of cold processing, e.g. cold drawing, turning or centreless grinding, is left to the manufacturer's discretion, provided that the requirements concerning tolerances on dimensions and surface roughness are respected.

d For information. IT = International tolerance, as defined in ISO 286-1, and in other dimensional tolerance standard.

e Specific tolerance within the ranges shall be agreed upon at the time of enquiry and order.

Table 5 — Mechanical properties for flat products in the usual delivery condition

Designation		Thickness[a]	Heat treatment[b]	Hardness[c,d]	Proof strength[e]		Tensile strength	Elongation after fracture[f]		
Line number	Name	t		HB	$R_{p0,2}$	$R_{p1,0}$	R_m	A_{80}		
		Flat products						$0,5 \leqslant t < 3$	$3 \leqslant t$	
		mm			MPa*		MPa*	%	%	%
		max.		max.	min.			min. (lg. + tr.)	min. lg.	min. tr.
Ferritic steels										
1	X2CrTi12	$0,5 \leqslant t \leqslant 12$	+A	—	210	—	380 to 560	25	25	25
2	X6Cr13	$0,5 \leqslant t \leqslant 12$	+A	197	230	—	400 to 630	18	20	18
3	X10CrAlSi13	$0,5 \leqslant t \leqslant 12$	+A	192	250	—	450 to 650	13	15	15
4	X6Cr17	$0,5 \leqslant t \leqslant 12$	+A	197	250	—	430 to 630	18	20	18
5	X10CrAlSi18	$0,5 \leqslant t \leqslant 12$	+A	212	270	—	500 to 700	13	15	15
6	X10CrAlSi25	$0,5 \leqslant t \leqslant 12$	+A	223	280	—	520 to 720	13	15	15
7	X15CrN26	$0,5 \leqslant t \leqslant 12$	+A	212	280	—	500 to 700	13	15	15
8	X2CrTiNb18	$0,5 \leqslant t \leqslant 12$	+A	—	230	—	430 to 630	18	18	18
9	X3CrTi17	$0,5 \leqslant t \leqslant 12$	+A	—	230	—	420 to 600	23	23	23
Austenitic steels										
10	X7CrNi18-9	$0,5 \leqslant t \leqslant 75$	+AT	192	195	230	500 to 700	37	40	
11	X7CrNiTi18-10	$0,5 \leqslant t \leqslant 75$	+AT	215	190	230	500 to 720	40	40	
12	X7CrNiNb18-10	$0,5 \leqslant t \leqslant 75$	+AT	192	205	240	510 to 710	28	30	
13	X15CrNiSi20-12	$0,5 \leqslant t \leqslant 75$	+AT	223	230	270	550 to 750	28	30	
14	X7CrNiSiNCe21-11	$0,5 \leqslant t \leqslant 75$	+AT	210	310	345	650 to 850	37	40	
15	X12CrNi23-13	$0,5 \leqslant t \leqslant 75$	+AT	192	210	250	500 to 700	33	35	
16	X8CrNi25-21	$0,5 \leqslant t \leqslant 75$	+AT	192	210	250	500 to 700	33	35	
17	X8NiCrAlTi32-21	$0,5 \leqslant t \leqslant 75$	+AT	192	170	210	450 to 680	28	30	
18	X6CrNiSiNCe19-10	$0,5 \leqslant t \leqslant 75$	+AT	210	290	330	600 to 800	30	40	
19	X6NiCrSiNCe35-25	$0,5 \leqslant t \leqslant 75$	+AT	210	300	340	650 to 850	40	40	

lg.: longitudinal

tr.: transverse

a For other thicknesses, the mechanical properties shall be negotiated.

b +A = annealed, +AT = solution annealed (see also Table B.1).

c For guidance only.

d For thin materials, the HRB or HV hardness test may be used, by agreement between the purchaser and manufacturer, where it is not practicable to use the HB test.

e The minimum value of $R_{p0,2}$ shall be determined, unless, in the case of austenitic steels, it has been agreed between the purchaser and manufacturer that the minimum of value $R_{p1,0}$ is required instead of that of $R_{p0,2}$.

f In the case of ferritic and austenitic steels, the values for flat products having a thickness $t \geqslant 3$ mm are valid for a gauge length of $L_o = 5,65\sqrt{S_o}$; for flat products of thickness $0,5 \leqslant t < 3$ mm, the values are valid for both test pieces specified in ISO 6892.

* 1 MPa = 1 N/mm^2.

Table 6 — Mechanical properties for long products in the usual delivery condition

Line number	Designation: Name	Thickness[a] product form: bars d mm max.	wire, rod and sections d mm max.	forgings d mm max.	Heat treatment[b]	Hardness[c, d, e, f] HB max.	Proof strength[f,g] $R_{p0,2}$ MPa * min.	$R_{p1,0}$ MPa * min.	Tensile strength[e] R_m MPa *	Elongation after fracture[h] A % min.
Ferritic steels										
1	X2CrTi12	$5 \leqslant d \leqslant 25$	$1{,}5 \leqslant d \leqslant 25$	$5 \leqslant d \leqslant 15$	+A	—	210	—	380 to 560	—
2	X6Cr13				+A	197	230	—	400 to 630	20
3	X10CrAlSi13				+A	192	250	—	450 to 650	15
4	X6Cr17				+A	197	250	—	430 to 630	20
5	X10CrAlSi18				+A	212	270	—	500 to 700	15
6	X10CrAlSi25				+A	223	280	—	520 to 720	10
7	X15CrN26				+A	212	280	—	500 to 700	15
8	X2CrTiNb18				+A	—	230	—	430 to 630	18
9	X3CrTi17				+A	—	230	—	420 to 600	—
Austenitic steels										
10	X7CrNi18-9	$5 \leqslant d \leqslant 160$	$1{,}5 \leqslant d \leqslant 25$	$d \leqslant 100$	+AT	192	195	230	500 to 700	40
11	X7CrNiTi18-10				+AT	215	190	230	500 to 720	40
12	X7CrNiNb18-10				+AT	192	205	240	510 to 710	30
13	X15CrNiSi20-12				+AT	223	230	270	550 to 750	30
14	X7CrNiSiNCe21-11				+AT	210	310	345	650 to 850	40
15	X12CrNi23-13				+AT	192	210	250	500 to 700	35e
16	X8CrNi25-21				+AT	192	210	250	500 to 700	35e
17	X8NiCrAlTi32-21				+AT	192	170	210	450 to 680	30
18	X6CrNiSiNCe19-10				+AT	210	290	330	600 to 800	40e
19	X6NiCrSiNCe35-25				+AT	210	300	340	650 to 850	40e

a For other dimensions, the mechanical properties shall be negotiated.

b +A = annealed, +AT = solution annealed (see also Table B.1).

c For guidance only.

d For thin materials, the HRB or HV hardness test may be used, by agreement between the user and manufacturer, where it is not practicable to use the HB test.

e The maximum HB values may be raised by 100 units or the maximum tensile strength value may be raised by 200 MPa and the minimum elongation value be lowered to 20 % for sections and bars of $\leqslant$ 35 mm thickness having a final cold deformation.

f For rods, only the tensile strength values apply.

g The minimum value of $R_{p0,2}$ shall be determined, unless, in the case of austenitic steels, it has been agreed between the purchaser and the manufacturer that the minimum of value $R_{p1,0}$ is required instead of that of $R_{p0,2}$.

h For diameters of $\geqslant$ 3 mm the values are valid for a gauge length of $L_o = 5{,}65\sqrt{S_o}$.

* 1 MPa = 1 N/mm^2.

Table 7 — Tests to be carried out, test units and extent of testing in specific testing for heat-resisting flat steel products

Test	a	Test unit	Product form			Number of test pieces per test sample
			Strip, sheet and cut length cut from strip in rolling width		Rolled plate (P)	
			< 600 mm	⩾ 600 mm		
Chemical analysis	m	Cast	The cast analysis is given by the manufacturer [b]			
Tensile test at room temperature	m	Same cast, same nominal thickness ± 10 %, same final treatment condition (i. e. same heat treatment and/or same degree of cold deformation)	The extent of testing shall be agreed at the time of ordering	One test sample from each coil	a) Plates processed under identical conditions may be collected into a batch, with a maximum total weight of 30 000 kg comprising no more than 40 plates. One test sample per batch shall be taken from heat-treated plates up to 15 m in length. One test sample shall be taken from each end of the longest plate in the batch where heat-treated plates are longer than 15 m. b) If the plate cannot be tested in batches, one test sample shall be taken from one end from heat-treated plates up to 15 m long, and one test sample shall be taken from each end of heat-treated plates longer than 15 m.	1

[a] Tests marked with an "m" (mandatory) shall be carried out as specific tests. In all cases, optional tests shall be carried out as specific tests only if agreed at the time of ordering.

[b] A product analysis may be agreed at the time of ordering; the extent of testing shall be specified at the same time.

Table 8 — Tests to be carried out, test units and extent of testing in specific testing for heat-resisting long steel products

Test	a	Test unit	Product form Wire, rod, bars and sections	Number of test pieces per sample
Chemical analysis	m	Cast	The cast analysis is given by the manufacturer [b]	
Tensile test at room temperature	m	Batch [c]	One sample per 25 t; maximum of two per test unit	1

[a] Tests marked with an "m" (mandatory) shall be carried out as specific tests. In all cases, optional tests shall be carried out as specific tests only if agreed at the time of ordering.

[b] A product analysis may be agreed at the time of ordering; the extent of testing shall be specified at the same time.

[c] Each batch consists of products coming from the same cast. The products must have been subject to the same heat-treatment cycle in the same furnace. In the case of a continuous furnace, or in process annealing, a batch is the lot that was heat treated without intermission with the same process parameters.

The shape and size of cross-sections of products in a single batch may be different providing that the ratio of the largest to the smallest areas shall be equal to or less than three.

Annex A
(informative)

International Standards for dimensions and tolerances

[1] ISO 286-1:1988, *ISO system of limits and fits — Part 1: Bases of tolerances, deviations and fits*

NOTE The remarks in Table 4 contain information concerning tolerances for bright bars; special agreements are necessary if such information should become obligatory.

[2] ISO 657-1:1989, *Hot-rolled steel sections — Part 1: Equal-leg angles — Dimensions*

[3] ISO 657-2:1989, *Hot-rolled steel sections — Part 2: Unequal-leg angles — Dimensions*

[4] ISO 657-5:1976, *Hot-rolled steel sections — Part 5: Equal-leg angles and unequal-leg angles Tolerances for metric and inch series*

[5] ISO 657-11:1980, *Hot-rolled steel sections — Part 11: Sloping flange channel sections (Metric series) — Dimensions and sectional properties*

[6] ISO 657-13:1981, *Hot-rolled steel sections — Part 13: Tolerances on sloping flange beam, column and channel sections*

[7] ISO 657-15:1989, *Hot-rolled steel sections — Part 15: Sloping flange beam sections (Metric series) — Dimensions and sectional properties*

[8] ISO 657-16:1980, *Hot-rolled steel sections — Part 16: Sloping flange column sections (metric series); dimensions and sectional properties*

[9] ISO 657-21:1983, *Hot-rolled steel sections — Part 21: T-sections with equal depth and flange width — Dimensions*

[10] ISO 1035-1:1980, *Hot-rolled steel bars — Part 1: Dimensions of round bars*

[11] ISO 1035-2:1980, *Hot-rolled steel bars — Part 2: Dimensions of square bars*

[12] ISO 1035-3:1980, *Hot-rolled steel bars — Part 3: Dimensions of flat bars*

[13] ISO 1035-4:1982, *Hot-rolled steel bars — Part 4: Tolerances*

[14] ISO 9444:2002, *Continuously hot-rolled stainless steel strip, plate/sheet and cut lengths — Tolerances on dimensions and form*

[15] ISO 9445:2002, *Continuously cold-rolled stainless steel narrow strip, wide strip, plate/sheet and cut lengths — Tolerances on dimensions and form*

[16] ISO 16124:2004, *Steel wire rod — Dimensions and tolerances*

[17] ISO 18286:2004, *Hot-rolled stainless steel plates — Tolerances on dimensions and shape*

Annex B
(informative)

Technical information on heat-resisting steels

B.1 General

The property values contained in the preceding specification are delivery requirements. The property values indicated in this annex are not delivery requirements. The data given in this annex are provided only as a guide for the heat treatment and for the relative performance of the different steels. Users should assure themselves of the actual properties achieved in practice.

B.2 Heat treatment

For information on heat-treatment, see Table B.1.

B.3 Heat resistance

The steels given in Table 1 have, by virtue of their alloy content, an increased resistance to attack by hot gases and combustion products. This resistance and, consequently, the maximum service temperature of the materials is, however, largely dependent on the conditions of attack. For use in clean air under conditions where the mechanical stresses (see Table B.3) are unimportant with regard to service life, the maximum service temperature indicated in Table B.2 can be taken as a guide.

A warning is given that, where the material is to be used in atmospheres other than clean air, then the values in Table B.2 should not be taken as applicable for the maximum temperature of use. In such cases, the rate of oxidation of the steels can be significantly increased, depending on their chemical composition, so that as a consequence the maximum temperature of use can be considerably reduced and could be, for example, several hundred degrees lower than the temperatures in Table B.2.

B.4 Creep resistance

In Table B.3, the average creep stresses for 1 % elongation ($R_{p1,0}$) and rupture (R_m) after durations of 1 000 h and 10 000 h are given for guidance only (see footnote b to Table B.3).

B.5 Physical properties

In Table B.4, the physical properties of the steels are given for guidance.

B.6 Technological properties

B.6.1 The steels are suitable for hot working. The optimum hot-working conditions shall, where necessary, be requested from the manufacturer.

B.6.2 The steels are suitable for cold forming. It is, however, recommended that ferritic steels be annealed before working. Furthermore, the marked tendency of austenitic steels to work-harden should be noted.

B.6.3 The steels may generally be welded by the usual welding processes. It is, however, recommended that users who have not had experience in welding these materials should consult the manufacturer regarding appropriate welding conditions. Additionally, the tendency of ferritic steels to grain growth when being welded should be taken into account.

Table B.1 — Heat treatment (for guidance only)

Line number	Type of steel	Heat treatment		
		Symbol[a]	Temperature[b] °C	Cooling[c]
Ferritic steels				
1	X2CrTi12	+A	800 ± 30	a, w
2	X6Cr13	+A	775 ± 25	a[f]
3	X10CrAlSi13	+A	825 ± 25	a, (w)[d]
4	X6Cr17	+A	800 ± 50	a, w,[f]
5	X10CrAlSi18	+A	825 ± 25	a, (w)[d]
6	X10CrAlSi25	+A	825 ± 25	a, (w)[d]
7	X15CrN26	+A	825 ± 25	a, (w)[d]
8	X2CrTiNb18	+A	900 ± 25	a, w
9	X3CrTi17	+A	800 ± 30	a, w
Austenitic steels				
10	X7CrNi18-9	+AT	1 050 ± 50	w, a[e]
11	X7CrNiTi18-10	+AT	1 070 ± 50	w, a[e]
12	X7CrNiNb18-10	+AT	1 070 ± 50	w, a[e]
13	X15CrNiSi20-12	+AT	1 100 ± 50	w, (a)
14	X7CrNiSiNCe21-11	+AT	1 070 ± 50	w, a
15	X12CrNi23-13	+AT	1 100 ± 50	w, a[e]
16	X8CrNi25-21	+AT	1 100 ± 50	w, a[e]
17	X8NiCrAlTi32-21	+AT	1 150 ± 50[f]	w, a
18	X6CrNiSiNCe19-10	+AT	1 070 ± 50	w, a[e]
19	X6NiCrSiNCe35-25	+AT	1 125 ± 25	w, a[e]

[a] +A = annealed; +AT = solution annealed.

[b] In the case where the heat treatment is performed in a continuous furnace, the upper part of the given temperature range, or even a temperature in excess of it, is normally preferred.

[c] a = air; f = furnace; w = water.

[d] In special cases, furnace cooling is also permitted.

[e] Cooling is sufficiently rapid.

[f] A grain size of 0 to 5 after heat treatment is recommended.