International Standard 4955

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

Heat-resisting steels and alloys

Aciers et alliages réfractaires

First edition — 1983-12-01

UDC 669.14.018.45 **Ref. No. ISO 4955-1983 (E)**

Descriptors : steels, heat resistant materials, heat resistant steels, nickel alloys, chromium containing alloys, ferritic steels, austenitic steels, specifications, chemical composition, hardness, mechanical properties, tensile properties, heat treatment, creep properties, physical properties, tests, test specimens, designation, certification.

Price based on 15 pages

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (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 authorized 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 4955 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in September 1982.

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

Austria	Iran	Spain
Belgium	Italy	Switzerland
Canada	Japan	Tanzania
China	Korea, Dem. P. Rep. of	Turkey
Czechoslovakia	Korea, Rep. of	United Kingdom
Egypt, Arab Rep. of	Netherlands	USA
France	Norway	USSR
Germany, F. R.	Poland	Venezuela
Hungary	Romania	
India	South Africa, Rep. of	

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

Australia
Sweden

Printed in Switzerland

Heat-resisting steels and alloys

1 Scope and field of application[1)]

1.1 This International Standard specifies requirements for the grades of wrought steels and alloys listed in tables 2 and 3 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.

NOTE — Steels which have an increased resistance to deformation when they are subjected for long periods to mechanical stresses are covered by ISO/TR 4956, *Wrought steels for use at elevated temperatures in engines*.[2)] Further heat-resisting steels and alloys for valves are covered by ISO 683/15, *Heat-treated steels, alloy steels and free-cutting steels — Part 15 : Valve steels for internal combustion engines*.

1.2 Unless otherwise stated, this International Standard applies to all types of hot-worked or cold-worked products which are supplied in one of the surface and heat-treatment conditions given in 3.3.

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

2 References

ISO/R 80, *Rockwell hardness test (B and C scales) for steel.*

ISO 82, *Steel — Tensile testing.*

ISO 86, *Steel — Tensile testing of sheet and strip less than* 3 mm *and not less than* 0,5 mm *thick.*

ISO 89, *Steel — Tensile testing of wire.*

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.*

ISO 683/13, *Heat-treated steels, alloy steels and free-cutting steels — Part 13 : Wrought stainless steels.*

ISO 6506, *Metallic materials — Hardness test — Brinell test.*

ISO 6507/1, *Metallic materials — Hardness test — Vickers test — Part 1 :* HV5 *to* HV100.

3 Requirements

3.1 Information to be supplied by the purchaser

3.1.1 The purchaser shall state in his enquiry and order the following :

a) the product form and the dimensions (see 3.9);

b) the type of material (see tables 2 and 3) and, if necessary, the condition of heat treatment at the time of delivery (see 3.3.1 and 3.3.2);

c) the requirement class (see table 1) and if called for, the kind of documentation required (see 4.5).

3.1.2 Furthermore, the relevant clause of ISO 404 is valid.

3.2 Production process

Unless otherwise agreed in the order, the steelmaking process used shall be at the discretion of the manufacturer. When he so requests, the purchaser shall be informed what process is being used.

3.3 Heat treatment and surface condition of delivery

3.3.1 The surface and heat treatment condition of delivery shall be agreed at the time of enquiry and order.

1) At the next revision of this International Standard, tubes and nickel alloys may be deleted.

2) In preparation.

3.3.2 Usual delivery conditions are

a) hot worked;

b) hot worked + heat treated;

c) hot worked + heat treated + descaled;

d) hot worked + descaled + cold worked + heat treated;

e) hot worked + descaled + cold worked + heat treated + descaled

However, not all product forms are necessarily available in all conditions as given above. Unless otherwise agreed at the time of enquiry and order, the heat treatment referred to in a) to e) above is identical with the heat treatment conditions given in tables 6 and 7.

3.4 Requirement classes[1)]

The steels covered by this International Standard shall be ordered and delivered in accordance with one of the requirement classes given in table 1.

3.5 Chemical composition

3.5.1 The chemical composition expressed by the cast analysis shall be in accordance with the corresponding requirements in tables 2 and 3.

3.5.2 The permissible deviation between the values specified in tables 2 and 3 and the product analysis are given in tables 4 and 5.

3.6 Mechanical properties

3.6.1 When ordering according to the requirement class 1a and to the heat treatment condition given in table 6, the maximum Brinell hardness values specified in table 6 shall apply.

3.6.2 When ordering according to the requirement class 5 and to the heat treatment condition given in table 6 the tensile properties specified in table 6 shall apply.

3.7 Further material properties

There are some further material properties for which, however, it is impossible at present to lay down clear requirements. As far as appropriate and possible, annex A gives technical information about these properties.

3.8 Surface quality

3.8.1 All products shall have a workmanlike finish and shall be clean and free from surface imperfections likely to have an adverse effect.

3.8.2 Hot-rolled, forged, cold-drawn or, rough-machined products shall be delivered with a machining allowance for the removal of, by machining or grinding, of

a) surface decarburization, and

b) surface imperfections.

As long as no International Standard for the machining allowances of heat-resisting steels and alloys is available, the allowance shall be agreed at the time of enquiry and order.

3.9 Dimensions and tolerances

3.9.1 Where possible the products shall be ordered and delivered in accordance with existing International Standards for dimensions and tolerances (see the list in annex B). The ordered dimensions shall, where applicable, include the minimum machining allowances.

3.9.2 If none of the International Standards listed in annex B is applicable, then the dimensions and tolerances shall be agreed at the time of enquiry and order.

4 Testing

4.1 Number of sample products

4.1.1 Chemical composition

If requested at the time of enquiry and order, the cast analysis shall be reported by the manufacturer. If a product analysis is required by the purchaser and unless otherwise agreed at the time of enquiry and order, one sample product shall be taken from each cast.

4.1.2 Mechanical properties

One sample product shall be tested for each cast and for each separate heat-treatment batch. All material from the same continuous heat-treatment operation during the same operating period is considered to be of the same heat-treatment batch.

4.2 Samples and test pieces

4.2.1 For product analyses, the selection of samples shall be carried out in conformity with the requirements of ISO/R 377.

4.2.2 For the Brinell hardness test, the surface of the sample product or of a test piece taken from the sample product in the delivery condition shall be prepared in accordance with the requirements in ISO 6506.

1) In previous International Standards dealing with this subject, the term "type of condition of delivery" was used instead of "requirement class". It was replaced in order to avoid confusion with the term "delivery condition" which is often used for the treatment condition of the steel at the time of delivery.

4.2.3 For the tensile test, one longitudinal test piece is to be taken

— for bars : according to figure 1 and ISO 82;

— for wire : according to figure 1 and ISO 82 or ISO 89;

— for tubes : according to figure 2 and ISO 82 or ISO 375;

— for flat products : in cases of dispute, according to figure 1 and ISO 82 or ISO 86; otherwise the manufacturer is permitted to use for flat products transverse test pieces taken in accordance with figure 3.

4.3 Test methods

4.3.1 In cases of dispute, the methods for the **chemical analysis** shall be those established by the relevant International Standard. If no International Standards are available, the methods may be agreed upon and specified at the time of enquiry and order.

4.3.2 The **Brinell hardness test** shall be made in accordance with ISO 6506.

4.3.3 The **tensile test** shall be made in accordance with ISO 82, ISO 86 or ISO 89, as appropriate.

4.4 Retest

For retests, see ISO 404.

4.5 Certification of the tests

For certification of the tests, the relevant clauses of ISO 404 are valid, acceptable documents being

a) statement of compliance with the order;

b) test report;

c) inspection certificate;

d) inspection report;

5 Surface and internal imperfections and complaints after delivery

The conditions given in ISO 404 are valid for

— surface imperfections;

— repairs;

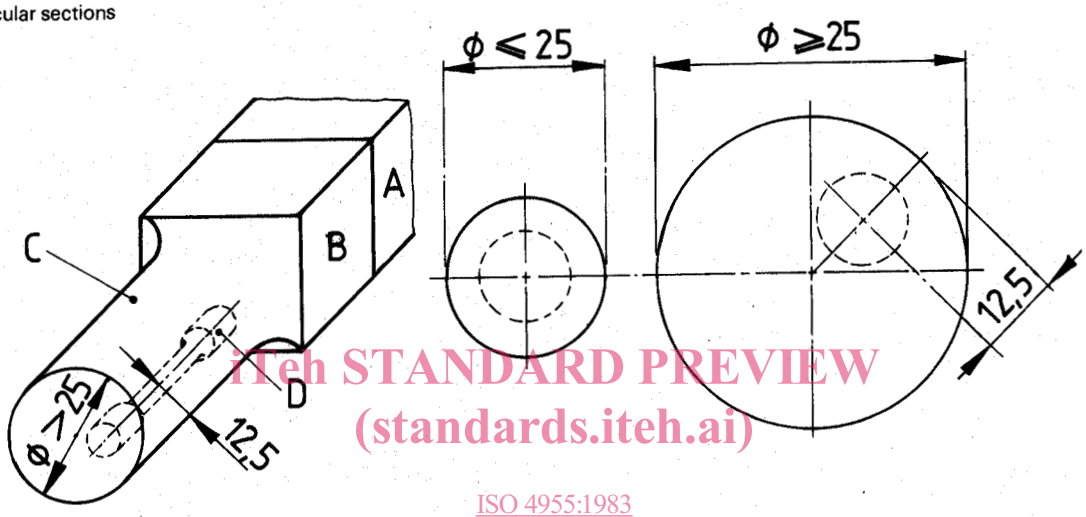
— internal imperfections;

— complaints after delivery.

Dimensions in millimetres

Test piece

Circular sections



A = Sample product

B = Test sample

C = Test bar (the piece after reduction to the size in which it is to be heat-treated)

D = Test piece

Rectangular sections

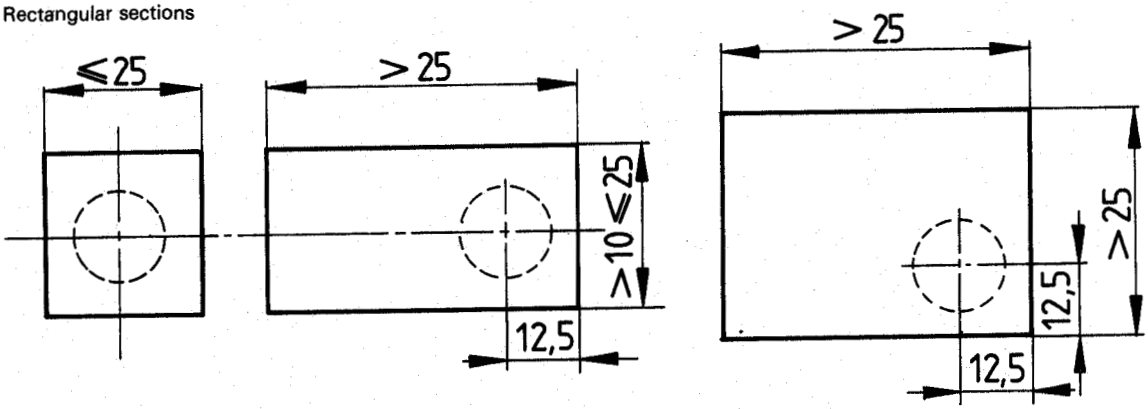
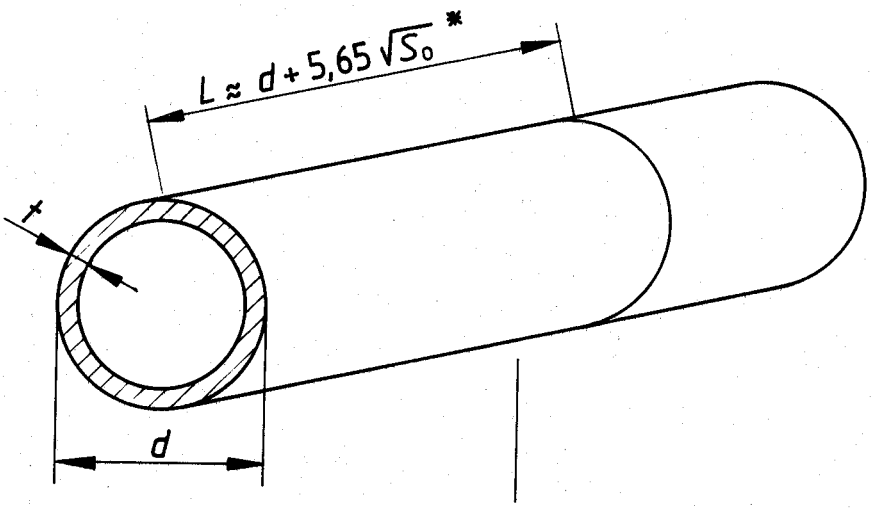


Figure 1 — Location of the tensile test pieces in bars and wire

1) Sample



2) Test piece

with a gauge length of $L_o = 5{,}65\sqrt{S_o}$ *

*S_o = cross-section of the test piece

a) Either a full section tensile test piece according to ISO 375

(Test piece identical with the sample drafted above)

or b) a round longitudinal tensile test piece according to ISO 82; taken as follows :

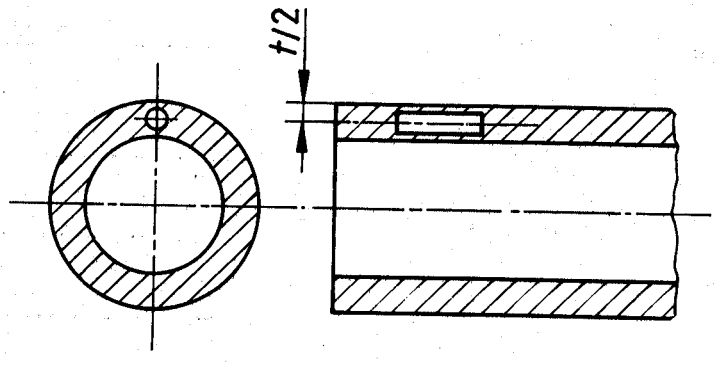
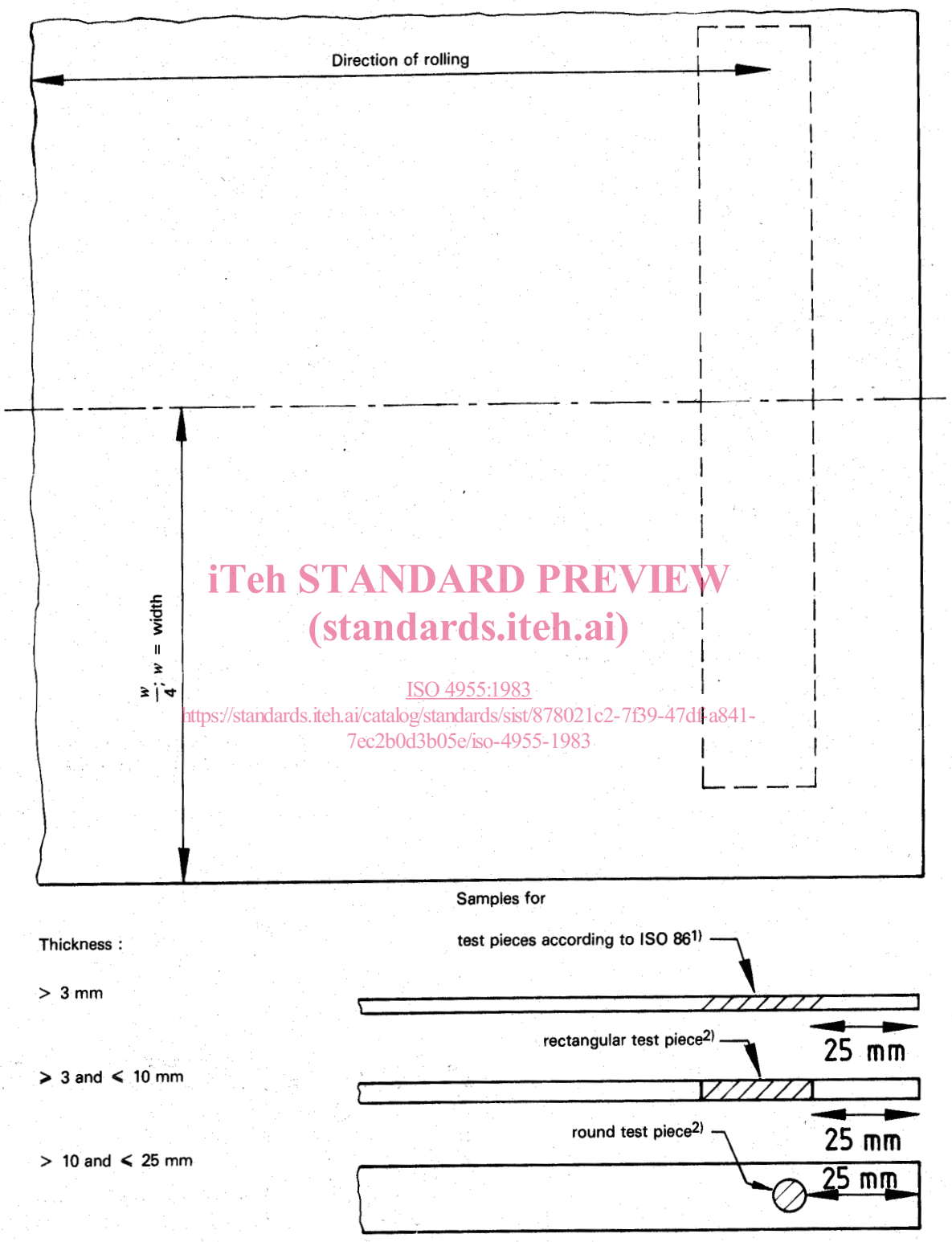


Figure 2 — Location and type of the tensile test pieces for tubes



1) ISO 86 recommends test pieces either of 20 mm width and 80 mm gauge length or of 12,5 mm width and 50 mm gauge length, the latter being only for thicknesses ⩾ 0,5 mm and < 2 mm. (The elongation values for test pieces must be agreed; seen footnote 5 in table 6.)

2) Gauge length in cases of dispute : $L_o = 5{,}65\sqrt{S_o}$ (S_o = cross-sectional area of the test piece).

Figure 3 — Location of the tensile test pieces in sheet, strip or plate (see 4.2.3)

Table 1 — Requirement classes

1	2	3		
No.	Requirement	Requirement to be observed in the case requirement class*		
		1	1a	5
1	Chemical composition	X	X	X
2	Hardness in the usual delivery condition	—	X	—
3	Tensile properties in the usual delivery condition	—	—	X

* The requirement class numbers are provisional. They will be finally fixed as soon as the International Standard on a system of the numbers and letters for the requirement classes has been established.

Table 2 — Types of steel and chemical composition specified
(applicable to cast analysis)[1)]

Type of steel	C % max.	Si %	Mn % max.	P % max.	S % max.	Cr %	Ni %	Other elements %	Type No. in ISO 683/13
Ferritic steels									
H 1	0,08	1,0 max.	1,0	0,040	0,030	10,5/12,5	—	Ti ⩾ 6 X % C ⩽ 1,00	
H 2	0,12	1,0 max.	1,0	0,040	0,030	12,0/14,0	—	—	≈ 1
H 3	0,12	0,70/1,4	1,0	0,040	0,030	12,0/14,0		Al 0,70/1,20	
H 4	0,10	1,0 max.	1,0	0,040	0,030	16,0/18,0	—	—	8
H 5	0,12	0,70/1,4	1,0	0,040	0,030	17,0/19,0	—	Al 0,70/1,20	
H 6	0,12	0,70/1,4	1,0	0,040	0,030	23,0/26,0	—	Al 1,20/1,70	
H 7	0,20	1,0 max.	1,0	0,040	0,030	24,0/28,0	—	N 0,15/0,25	
Austenitic steels									
H 10	0,12	1,0 max.	2,0	0,045	0,030	17,0/19,0	8,0/10,0	—	12
H 11	0,12	1,0 max.	2,0	0,045	0,030	17,0/19,0	9,0/12,0	Ti ⩾ 5 X % C ⩽ 0,80	≈ 15
H 12	0,12	1,0 max.	2,0	0,045	0,030	17,0/19,0	9,0/12,0	Nb ⩾ 8 X % C ⩽ 1,20[2)]	≈ 16
H 13	0,20	1,5/2,5	2,0	0,045	0,030	19,0/21,0	11,0/13,0	—	
H 14	0,08	1,0 max.	2,0	0,045	0,030	22,0/24,0	12,0/15,0	—	
H 15	0,08	1,5 max.	2,0	0,045	0,030	24,0/26,0	19,0/22,0	—	
H 16	0,20	1,5/2,5	2,0	0,045	0,030	24,0/26,0	19,0/22,0	—	
H 17	0,15	1,0/2,0	2,0	0,045	0,030	15,0/17,0	33,0/37,0	—	
H 18	0,12[4)]	1,0 max.	2,0	0,045	0,030	19,0/23,0	30,0/34,0	Al 0,15/0,60; Ti 0,15/0,60	TS 69, P 69[3)]

1) Elements not quoted in the table shall not be intentionally added without the agreement of the purchaser, other than for the purpose of finishing the heat. All reasonable precautions shall 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.

2) Tantalum determined as niobium.

3) See ISO 2604, *Steel products for pressure purposes — Quality requirements — Part 2 : Wrought seamless tubes*, and *Part 4 : Plates*.

4) A minimum of 0,05 % C shall also apply.

Table 3 — Types of alloys and chemical composition specified
(applicable to cast analysis)

Type of alloy	C %	Si % max.	Mn % max.	S % max.	Al % max.	Co % max.	Cr %	Cu % max.	Fe %	Ni %	Ti %	Other elements %
H 20	⩽ 0,15	0,5	1,0	0,015	0,4[1)]	1,0	14,0/17,0	0,5	6,0/10,0	⩾ 72,0	⩽ 0,5	
H 21	0,08/0,15	1,0	1,0	0,020	—	5,0	18,0/21,0	0,5	⩽ 5,0	Remainder	0,2/0,6	
H 22	⩽ 0,10	0,5	0,5	0,015	0,4	1,0	20,0/23,0	—	⩽ 5,0	Remainder	⩽ 0,45	Mo : 8,0/10,0 Nb + Ta : 3,2/4,2

1) If aluminium is determined.

Table 4 — Permissible deviation between specified analysis and product analysis for the steels
(see table 2)

Type of steel	Permissible deviations[1)], %							
	C %	Si %	Mn %	P %	S %	Cr %	Ni	Other elements %
Ferritic steels								
H 1	+ 0,01	+ 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,15	—	Ti ± 0,05
H 2	+ 0,01	+ 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,15	—	—
H 3	+ 0,01	± 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,15	—	Al ± 0,10
H 4	+ 0,01	+ 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,20	—	—
H 5	+ 0,01	± 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,20	—	Al ± 0,10
H 6	+ 0,01	± 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,25	—	Al ± 0,10
H 7	+ 0,01	+ 0,05	+ 0,04	+ 0,005	+ 0,005	± 0,25	—	N ± 0,02
Austenitic steels								
H 10	+ 0,01	+ 0,05	+ 0,04	+ 0,010	+ 0,005	± 0,20	± 0,10	—
H 11	+ 0,01	+ 0,05	+ 0,04	+ 0,010	+ 0,005	± 0,20	± 0,15	Ti ± 0,05
H 12	+ 0,01	+ 0,05	+ 0,04	+ 0,010	+ 0,005	± 0,20	± 0,15	Nb ± 0,05
H 13	+ 0,01	± 0,10	+ 0,04	+ 0,010	+ 0,005	± 0,20	± 0,15	—
H 14	+ 0,01	+ 0,05	+ 0,04	+ 0,010	+ 0,005	± 0,25	± 0,15	—
H 15	+ 0,01	+ 0,10	+ 0,04	+ 0,010	+ 0,005	± 0,25	± 0,20	—
H 16	+ 0,01	± 0,10	+ 0,04	+ 0,010	+ 0,005	± 0,25	± 0,20	—
H 17	+ 0,01	± 0,10	+ 0,04	+ 0,010	+ 0,005	± 0,20	—	Al ± 0,05 Ti ± 0,05
H 18	± 0,01	+ 0,05	+ 0,04	+ 0,010	+ 0,005	± 0,25	± 0,20	

1) ± means that in one cast the deviation may occur over the upper or under the lower value of the specified range in table 2, but not both at the same time.

Table 5 — Permissible deviation between specified analysis and product analysis for the alloys
(see table 3)

Type of alloy	Permissible deviations[1)]											
	C %	Si %	Mn %	S %	Al %	Co %	Cr %	Cu %	Fe %	Ni %	Ti %	Other elements %
H 20	+ 0,01	+ 0,05	+ 0,03	+ 0,005	+ 0,05	+ 0,10	± 0,20	+ 0,05	± 0,10	−0,25	+ 0,05	
H 21	± 0,01	+ 0,05	+ 0,03	+ 0,005	—	+ 0,10	±0,25	+ 0,05	+ 0,10	—	± 0,05	
H 22	+ 0,01	+ 0,05	+ 0,03	+ 0,005	+ 0,05	+ 0,10	± 0,25	—	+ 0,10	—	+ 0,05	Mo : ± 0,10 (Nb + Ta) : ± 0,05

1) ± means that in one cast the deviation may occur over the upper or under the lower value of the specified range in table 3, but not both at the same time.

Table 6 — Hardness and tensile properties for the steels and alloys in the usual delivery condition

Type of steel or alloy	Product	Thickness mm	Heat treatment[1]	Mechanical properties[2]				
				HB[3] max.	$R_{p\,0,2}$[4] min. N/mm²	$R_{p\,1,0}$[4] min. N/mm²	R_m N/mm²	A_5[5] min. %
Ferritic steels								
H 1	Plate resp. sheet	⩾ 0,5 ⩽ 5	A	179	210[6]		400/600[6]	25[6]
H 2	Strip	⩾ 0,5 ⩽ 5	A	192	250	—	450/650	20
H 3	Tubes[7]	⩾ 0,5 ⩽ 5	A	192	250	—	450/650	15
H 4	Bars	⩾ 5 ⩽ 15	A	192	250	—	450/650	18
H 5	Forgings	⩾ 5 ⩽ 15	A	212	270	—	500/700	15[8]
H 6	Wire	⩾ 1,5 ⩽ 15	A	223	280	—	520/720	10
H 7			A	212	280	—	500/700	15
Austenitic steels								
H 10			Q	192	210	250	500/700	40
H 11	Plate resp. sheet	⩾ 0,5 ⩽ 30	Q	192[9]	210	250	500/700[9]	35
H 12	Strip	⩾ 0,5 ⩽ 5	Q	192[9]	210	250	500/700[9]	35
H 13	Tubes	⩾ 0,5 ⩽ 20	Q	223	230	270	550/750	30
H 14	Bars	⩽ 100	Q	192	210	250	500/700	35
	Forgings	⩽ 100						
H 15	Wire	⩾ 1,5 ⩽ 15	Q	192	210	250	500/700	35
H 16			Q	223	230	270	550/750	30
H 17			Q	223	230	270	550/750	30
H 18			Q	192	170	210	450/680	30
Iron/Nickel alloys								
H 20	Strip, sheet	< 0,25	Q	—	—	—	⩾ 550	—
	resp. plate	⩾ 0,25	Q	217	240		⩾ 550	30
	Bars	⩽ 25	Q	311	240		⩾ 550	30
		> 25 ⩽ 63	Q	285	240		⩾ 550	30
		> 63	Q	217	240		⩾ 550	30
	Tubes, HW[10]		Q	217	210		⩾ 550	30
	Tubes, CW[10]		Q		240		⩾ 550	30
H 21	Bars	⩾ 5,0	Q	235	230		⩾ 640	30
	Strip, sheet HW[10]	⩾ 0,5	Q	235	230		640/830	30
	resp. plate CW[10]	⩾ 0,5	Q	235	300		690/830	30
	Tubes	⩾ 0,5	Q	235	300		690/830	30
	Wire	⩾ 1 ⩽ 10	Q		—		640/830	—
H 22	Strip, sheet	< 0,25	Q	—	—		⩾ 830	—
	resp. plate	⩾ 0,25	Q	285	410		⩾ 830	30
	Bars	⩾ 5,0	Q	285	410		⩾ 830	30

1) A = annealed; Q = quenched (see also table 7).

2) $R_{p\,0,2}$ = 0,2 % proof stress
$R_{p\,1,0}$ = 1,0 % proof stress
R_m = tensile strength
A_5 = percentage elongation after fracture of longitudinal test pieces with a gauge length of $L_o = 5\,d_o$ (d_o = diameter of the round test piece) or $L_o = 5{,}65\sqrt{S_o}$ (S_o = area of cross-section of rectangular test pieces within the gauge length). For other gauge lengths the values shall be agreed.
1 N/mm² = 1 MPa

3) For thin materials, the HRB or HRC hardness test according to ISO/R 80 or the HV hardness test according to ISO 6507/1 may be used by agreement between user and steel manufacturer, where it is not practicable to use the HB test.

4) The $R_{p\,0,2\,min}$ value shall be determined unless in the case of austenitic steels it has been agreed between the purchaser and supplier that the $R_{p\,1,0\,min}$ value is required instead of the $R_{p\,0,2\,min}$ value.

5) The values apply for test pieces with thicknesses ⩾ 3 mm. For smaller thicknesses, the values shall be agreed at the time of enquiry and order.

6) If tensile properties are required they are to be confirmed at the time of enquiry and order.

7) Only applicable for cold-finished tubes.
For hot-finished tubes, the applicability of the values specified for the hardness and tensile properties should be agreed at the time of enquiry and order.

8) For tubes $A_{5\,min}$ may be 3 % lower.

9) For cold-rolled products, the hardness value can be ⩽ 223 HB and the upper limit of the tensile strength 750 N/mm².

10) HW = hot worked; CW = cold worked.