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Heat-treated steels, alloy steels and free-cutting steels — Part 12 : Flame and induction hardening steels

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FOREWORD

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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.

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It was approved in December 1971 by the Member Bodies of the following countries:

Australia	Germany	South Africa, Rep. of
Austria	Hungary	Sweden
Belgium	India	Switzerland
Czechoslovakia	Italy	Thailand
Denmark	Netherlands	Turkey
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France	Romania	

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Heat-treated steels, alloy steels and free-cutting steels — Part 12 : Flame and induction hardening steels

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the grades of wrought unalloyed and alloyed steels for flame and induction hardening listed in Table 2 and usually intended for use in the quenched and tempered and subsequently flame or induction hardened condition.

2 REFERENCES

ISO/R 79, *Brinell hardness test for steel*.

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

ISO/R 82, *Tensile testing of steel*.

ISO/R 83, *Charpy impact test (U-notch) for steel*.

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

ISO/R 404, *General technical delivery requirements for steel*.

ISO/R 642, *Hardenability test by end quenching steel (Jominy test)*.

ISO/R 643, *Micrographic determination of the austenitic grain size of steels*.

3 REQUIREMENTS

3.1 Production processes

3.1.1 Unless otherwise agreed in the order, the processes used in making the steel and the product are left to the discretion of the manufacturer, but the steel shall be killed. When he so requests, the user shall be informed what steelmaking process is being used.

3.1.2 It is recommended that the grain size of the steel — as defined in ISO/R 643 — is 5 or finer.

3.2 Chemical composition, mechanical properties and hardenability

3.2.1 Types of condition of delivery

The steels covered by this International Standard shall be ordered and delivered in accordance with Table 1. The type

of condition of delivery according to Table 1 shall be stated at the time of enquiry and order.

3.2.2 Chemical composition

The chemical composition expressed by the cast analysis shall be in accordance with Table 2.

3.2.2.1 If ordered to conditions of delivery type 1 or 1(a) (see Table 1), the following deviations between the limiting values specified in Table 2 and the product analysis of products up to 160 mm (6.3 in) diameter or equivalent dimensions shall apply. Above 160 mm (6.3 in) diameter, the deviations shall be stated at the time of enquiry and order.

3.2.2.2 If ordered to types of condition of delivery 2, 2(a), 3, 3(a), 4, 4(a), 4(g), 5 and 5(g), the mechanical properties or hardenability and ability to surface harden specified in Tables 4, 7 and 8 shall be the governing criteria for acceptance. In such cases, the cast analysis may deviate slightly from the figures shown in Table 2.

3.2.3 Mechanical properties

3.2.3.1 If specified, the mechanical properties shall be those shown in Tables 4, 5, 6, 7 or 8.

3.2.3.1.1 The values apply to test pieces, taken on rounds in the direction of the metal fibre, the axis of the test piece corresponding to that shown in Figure 1.

3.2.3.1.2 For rectangular sections, the ranges for equivalent diameters are given in Figure 2.

3.2.3.1.3 For other sections, the equivalent diameter shall be agreed at the time of enquiry and order.

3.2.3.2 The mechanical properties in the quenched and tempered condition as given in Table 4 are those which can be obtained for one of the conditions given below:

1) For a reference test bar of 16 mm diameter, taken from the product to be delivered either by machining

TABLE 1 — Types of condition of delivery

Requirements	Types of condition of delivery ¹⁾										
	1	1(a)	2	2(a)	3	3(a)	4	4(a)	4(g)	5	5(g)
Chemical composition	X	X	X	X	X	X	X	X	X	X	X
Hardenability (end quench test)	—	—	X	X	—	—	—	—	—	—	—
Hardness in a condition of delivery other than quenched and tempered	—	X	—	X	—	X	—	X	X	—	—
Surface hardness after surface hardening	—	—	—	—	—	—	—	—	X	—	X
Mechanical properties of											
— quenched and tempered test bar of 16 mm diameter	—	—	—	—	X	X	—	—	—	—	—
— quenched and tempered ruling section ²⁾	—	—	—	—	—	—	X	X	X	—	—
— quenched and tempered product in dimensions of delivery	—	—	—	—	—	—	—	—	—	X	X

1) The numbers indicating the types of condition of delivery follow a coordinated series of numbers throughout all relevant ISO publications.

2) See footnote to clause 3.2.3.2 (2).

TABLE 2 — Types of steel and chemical composition guaranteed
(applicable to cast analysis)¹⁾

Type of steel	C %	Si %	Mn %	P % max.	S % ²⁾ max.	Cr %	Mo %	Ni %
1	0.33 to 0.39	0.15 to 0.40	0.50 to 0.80	0.035	0.035			
2	0.38 to 0.44	0.15 to 0.40	0.50 to 0.80	0.035	0.035			
3	0.43 to 0.49	0.15 to 0.40	0.50 to 0.80	0.035	0.035			
4	0.48 to 0.55	0.15 to 0.40	0.60 to 0.90	0.035	0.035			
5	0.50 to 0.57	0.15 to 0.40	0.40 to 0.70	0.035	0.035			
6	0.42 to 0.48	0.15 to 0.40	0.50 to 0.80	0.035	0.035	0.40 to 0.60		
7	0.34 to 0.40	0.15 to 0.40	0.60 to 0.90	0.035	0.035	0.90 to 1.20		
8	0.38 to 0.44	0.15 to 0.40	0.60 to 0.90	0.035	0.035	0.90 to 1.20		
9	0.38 to 0.44	0.15 to 0.40	0.50 to 0.80	0.035	0.035	0.90 to 1.20	0.15 to 0.30	
10	0.38 to 0.44	0.15 to 0.40	0.70 to 1.00	0.035	0.035	0.40 to 0.60	0.15 to 0.30	0.40 to 0.70
11	0.37 to 0.43	0.15 to 0.40	0.50 to 0.80	0.035	0.035	0.60 to 0.90	0.15 to 0.30	0.70 to 1.00

1) Elements not quoted in the table shall not be intentionally added to the steel 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 manufacture, which affect the hardenability, mechanical properties and applicability.

2) By agreement at the time of enquiry and order, the steels can be supplied with a controlled sulphur content of 0.020 to 0.035 %.

TABLE 3 — Permissible deviations between specified analysis and product analysis

Type of steel	Permissible deviations ¹⁾							
	C %	Si %	Mn %	P %	S %	Cr %	Mo %	Ni %
1 to 5	± 0.03	± 0.03	± 0.04	+ 0.005	+ 0.005	—	—	—
6, 7, 8	± 0.02	± 0.03	± 0.04	+ 0.005	+ 0.005	± 0.05	—	—
9	± 0.02	± 0.03	± 0.04	+ 0.005	+ 0.005	± 0.05	± 0.03	—
10, 11	± 0.02	± 0.03	± 0.04	+ 0.005	+ 0.005	± 0.05	± 0.03	± 0.03

1) ± 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 in Table 2 but not both at the same time.

from a location according to Figure 1 or by forging, and then quenched and tempered according to the temperatures and times listed in Table 9 (types of condition of delivery 3 and 3(a) of Table 1).

2) For a ruling section¹⁾, to be specified at the time of enquiry and order, which is quenched and tempered according to the temperatures listed in Table 9 (types of condition of delivery 4, 4(a) and 4(g) of Table 1).

For location of the test bar, see 4.2.1.

3) For the product to be delivered in the quenched and tempered condition of delivery (types of condition of delivery 5 and 5(g) of Table 1).

For location of the test bar, see 4.2.1.

3.2.3.3 If the products are delivered in a condition other than quenched and tempered, a maximum hardness according to Table 5, measured after preparation of the surface in the conventional manner, may be agreed in addition to the other requirements (types of condition of delivery 1(a), 2(a), 3(a), 4(a) and 4(g) of Table 1).

Mechanical properties for the normalized condition for the types of steel 1 to 5 are given for information in Table 6.

3.2.3.4 When ordering on hardenability (types of condition of delivery 2 and 2(a) of Table 1), the Rockwell C hardness numbers given in Table 7 and the scatter bands in Figure 3 apply.

3.2.3.5 When it is required that the ability to harden on the surface be checked, this shall be stated in the enquiry and order (types of condition of delivery 4(g) and 5(g) of

1) In the selection of a steel, one of the most important considerations is whether the mechanical properties required can be obtained from the steel in the size and shape at the time of heat treatment. That portion, which is most important from the point of view of the mechanical properties obtained by heat treatment, is referred to as the ruling section, and the ruling section shall always be expressed in terms of the diameter of an equivalent round bar (see Figure 2).

Table 1). In this case, the values specified in Table 8 shall be taken as basis.

3.3 Tolerances on dimensions and mass

The tolerances allowable on dimensions and mass shall be stated in the order, as long as there are no ISO International Standards to cover them.

4 TESTING

4.1 Number of sample products

4.1.1 Chemical composition

The cast analysis is given by the manufacturer. If a product analysis is required by the purchaser, at least one sample product shall be taken from each cast.

4.1.2 Mechanical properties and hardenability

4.1.2.1 For material not supplied in the finally heat-treated condition (types of condition of delivery 1(a), 2, 2(a), 3, 3(a), 4, 4(a) and 4(g) of Table 1), one sample product shall be taken from each cast for testing in accordance with the requirements of Tables 4, 5, 6, 7 and 8 where applicable.

4.1.2.2 For material supplied in the finally heat-treated condition (types of condition of delivery 5 and 5(g) of Table 1), one sample product shall be taken from each size grouping from each heat treatment batch for testing in accordance with Table 4. If the product is continuously heat-treated, one sample product for each 25 t or part thereof for the carbon steels 1 to 5, for each 15 t or part thereof for the alloy steels 6 to 11, but at least one sample product for each cast, shall be taken.

4.2 Samples and test pieces

4.2.1 The test pieces for tensile test and impact test shall be taken in the longitudinal direction of the products according to Figure 1.