

# INTERNATIONAL STANDARD

**ISO**  
**683-18**

Second edition  
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## Heat-treatable steels, alloy steels and free-cutting steels —

### Part 18:

Bright products of unalloyed and low alloy  
steels

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ISO 683-18:1996

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Aciers pour traitement thermique, aciers alliés et aciers pour  
décolletage

Partie 18: Produits blancs en aciers non alliés et faiblement alliés



Reference number  
ISO 683-18:1996(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.

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.

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International Standard ISO 683-18 was prepared by Technical Committee ISO/TC 17, Steel, Subcommittee SC 4, *Heat treatable and alloy steels*.

This second edition cancels and replaces the first edition (ISO 683-18:1976), of which it constitutes a technical revision.

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ISO 683 consists of the following parts, under the general title *Heat-treatable steels, alloy steels and free-cutting steels*:

- Part 1: *Direct-hardening unalloyed and low-alloyed wrought steel in form of different black products*
- Part 9: *Wrought free-cutting steels*
- Part 10: *Wrought nitriding steels*
- Part 11: *Wrought case-hardening steels*
- Part 13: *Wrought stainless steels*
- Part 14: *Hot-rolled steels for quenched and tempered springs*
- Part 15: *Valve steels for internal combustion engines*
- Part 16: *Precipitation hardening stainless steels*
- Part 17: *Ball and roller bearing steels*
- Part 18: *Bright products of unalloyed and low alloy steels*

Annexes A and B of this part of ISO 683 are for information only.

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# Heat-treatable steels, alloy steels and free-cutting steels —

## Part 18:

### Bright products of unalloyed and low alloy steels

#### 1 Scope

**1.1** This part of ISO 683 applies to wrought unalloyed and alloyed steels in the form of bright products which are intended for mechanical purposes, for example for machine parts. It is subdivided as follows:

- a) clauses 5 and 6: general requirements and tests;
- b) clause 7: Case-hardening steels;
- c) clause 8: steels for quenching and tempering.

**1.2** In addition to this part of ISO 683, the general technical delivery requirements of ISO 404 are applicable.

#### 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 683. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 683 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 83:1976, *Steel — Charpy impact test (U-notch)*.

ISO 148:1983, *Steel — Charpy impact test (V-notch)*.

ISO 377-1:1989, *Selection and preparation of samples and test pieces of wrought steels — Part 1: Samples and test pieces for mechanical test*.

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

ISO 642:1979, *Steel — Hardenability test by end quenching (Jominy test)*.

ISO 643:1983, *Steels — Micrographic determination of the ferritic or austenitic grain size*.

ISO 4948-1:1982, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*.

ISO 4948-2:1981, *Steels — Classification — Part 2: Classification of unalloyed and alloy steels according to main quality classes and main property or application characteristics*.

ISO 6506:1981, *Metallic materials — Hardness test — Brinell test*.

ISO 6892:1984, *Metallic materials — Tensile testing*.

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

ISO 9443:1991, *Heat-treatable and alloy steels — Surface quality classes for hot-rolled round bars and wire rods — Technical delivery conditions*.

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 Definitions

For the purposes of this part of ISO 683, the relevant definitions given in ISO 4948-1, ISO 4948-2 and ISO 6929, and also the definition given in 3.4, apply.

#### 3.1 Bright products

For definition of drawn products, turned (or peeled) products and ground products, see ISO 6929.

#### 3.2 Unalloyed and alloyed steel

See ISO 4948-1.

#### 3.3 Special steel

See ISO 4948-2.

#### 3.4 Thickness

Thickness is considered to be the nominal dimension of the product, that means:

- the diameter in the case of rounds;
- the lateral length in the case of squares;
- the width over flats in the case of hexagons;
- the shorter lateral length in the case of flats.

### 4 Ordering

**4.1** The purchaser shall state in this enquiry and order

- a) the dimensions and tolerances of the product (see 5.10);
- b) the steel type (see tables 3, 7, 8, 11, 15, 16 and 17);
- c) the treatment condition (see 5.3.1);
- d) the surface-coating treatment, if any (see 5.3.2);
- e) the required type of document (see 6.1).

**4.2** Certain options in ordering are permitted by this part of ISO 683. The purchaser may also state in his enquiry and order his related requirements as shown in table 1.

**Table 1 — Permitted options in ordering**

For steels of tables	Permitted options
3, 11	f) whether a product analysis is required (see 6.2.1);
3, 11	g1) the choice of the surface quality class selected from ISO 9443 (see 5.8.1.5); g2) whether special specifications for the limits of surface defects are required (see 5.8.1.6);
3, 11	h) whether, specifically, coarse or fine grain steel is required (see 5.7);
3, 11	i) whether, for special steels, the microscopically determined non-metallic inclusion content shall be within agreed limits (see 5.9.2);
11	j) whether, for drawn products, special specifications for the permissible depth of the ferritic-pearlitic decarburization are required (see 5.8.2.1).

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### 5 General requirements

#### 5.1 Manufacture of the steel and of the product

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

**5.1.2** The steels shall be killed.

#### 5.2 Cast separation

The steels are delivered by casts.

#### 5.3 Treatment condition at the time of delivery

**5.3.1** The treatment and heat-treatment condition (if any) at the time of delivery must comply with the condition agreed in the order and shall be one of the conditions indicated in table 2 or 10. (See also 5.8.1.)

**5.3.2** Bright steel is supplied commercially with a light coating of grease, provided that nothing to the contrary is laid down in the regulations of the freighter regarding unpacked piece goods.

The usual light application of ordinary grease does not afford positive protection against rusting, particularly in the presence of water due to condensation. The use of a selected rust inhibitor or a special type of packing shall, if required, be agreed upon at the time of enquiry and order.

#### 5.4 Survey of combinations of usual treatment conditions on delivery and requirements

Tables 2 and 10 give a survey of combinations of usual treatment conditions on delivery and requirements concerning chemical composition, mechanical properties and hardenability.

#### 5.5 Chemical composition

**5.5.1** The chemical composition of the steels, determined by the cast analysis, shall be in accordance with the specifications in tables 3 and 11 (see 5.5.3).

**5.5.2** Tables 4 and 12 give the permissible deviations between the values given in tables 3 and 11 and those from the product analysis.

**5.5.3** If case-hardening or direct-hardening steels are ordered by using the designations given in tables 7, 8, 15, 16 or 17 to hardenability requirements for Jominy test pieces, the hardenability values shall be regarded as the governing criteria for acceptance. In such cases, the cast analysis may deviate from the values shown in tables 3 and 11 by the values given in footnote 1) to table 3 and footnote 3) to table 11.

#### 5.6 Hardenability and mechanical properties

The products shall fulfil the specifications of 7.2.3 and 8.2.3.

#### 5.7 Structure

If a controlled austenitic grain size is required, the austenitic grain size of the steel determined in accordance with 6.3.4 shall be 5 and finer for fine grain steels and 1 to 5 for coarse grain steels. The grain structure shall be considered satisfactory if 70 % is within the specified limits.

#### 5.8 Outer soundness

##### 5.8.1 Surface quality

**5.8.1.1** In the case of hexagons, squares, flats and special sections, the achievement of a light bright surface is precluded by the manufacturing methods used; the surface is darker than that of bright rounds.

**5.8.1.2** Heat treatment (e.g. stress relieving, soft annealing, normalizing, quenching and tempering) applied after drawing, centreless turning, grinding or polishing makes the surface darker and rougher.

**5.8.1.3** Pitting, scars and grooves are permitted on a localized scale; in the case of rounds, their depth shall not be greater than ISO tolerance zone h11.

In the case of bright products with different shapes, comparative samples may be agreed upon at the time of enquiry and order.

**5.8.1.4** If a surface quality that is superior to that obtained from the usual method of drawing once only or by centreless turning is required, an additional treatment (e.g. redrawing, grinding or polishing) may be agreed upon at the time of enquiry and order.

This is in particular necessary for a light bright and very smooth surface which may be needed for electrolytic surface coating.

**5.8.1.5** Longitudinal surface defects cannot be completely avoided when rolling and they are retained when drawing. Therefore, in the case of drawn products, agreements may be made concerning the permissible depth of such defects and their examination.

In the case of rounds, these agreements shall be based on ISO 9443.

**5.8.1.6** If special requirements concerning the limits of surface defects exist, the products shall be centreless-turned in a suitable way, and shall also be ground to improve the surface microstructure of rounds. Such requirements shall be agreed upon, if necessary, at the time of enquiry and order.

##### 5.8.2 Decarburization

**5.8.2.1** Drawn products of the steels in table 11 shall, independent of their heat-treatment conditions, be free from completely ferritic decarburized zones.

For such products, values for the permissible depth of the partial (ferritic-pearlitic) decarburization may be agreed upon at the time of enquiry and order.

**5.8.2.2** Bright products of the steels in tables 3 or 11 which, according to the order, were peeled or ground or polished shall be free from decarburization.

## 5.9 Internal soundness

**5.9.1** The steel shall be free from internal defects likely to have an adverse effect during further processing or use.

**5.9.2** Where appropriate, exact criteria for the compliance of the steel with the general requirement in 5.9.1 shall be agreed upon at the time of enquiry and order.

Agreements on the content of non-metallic inclusions, for example in accordance with ISO 4967 or other suitable methods, may be made for special steels.

## 5.10 Dimensions, tolerances on dimensions and masses

The products shall, if possible, be ordered in accordance with existing International Standards for dimensions and also tolerances on dimensions and masses.

If corresponding International Standards for dimensions and tolerances are not yet available, the dimensions and tolerances shall be agreed upon at the time of enquiry and order.

## 6 Testing

### 6.1 Agreement of tests and documents

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

**6.1.2** If, in accordance with such an agreement, specific inspection is to be carried out, the specifications in 6.2 to 6.5 shall be observed.

### 6.2 Test unit and number of sample products and tests

#### 6.2.1 Chemical composition

The cast analysis, if called for in the order, shall be provided by the manufacturer.

If a product analysis is required by the purchaser, and if not otherwise agreed at the time of enquiry and order, one sample product shall be taken from each cast.

### 6.2.2 Hardenability, mechanical properties, structure, inner and outer soundness

If, according to the ordered requirements (see tables 2 and 10) and the required type of document (see 6.1), the hardenability, mechanical properties, structure or inner and outer soundness are to be verified, then the indications in table 9 or 18 apply for the test unit and the number of samples and test pieces.

### 6.3 Selection and preparation of samples and test pieces

#### 6.3.1 General

The general conditions given in ISO 377-1 and ISO 14284 for the selection and preparation of samples and test pieces shall apply.

#### 6.3.2 Hardenability test

In cases of dispute, for the end-quench hardenability test, if possible the sampling method given in ISO 642:1979 [ 5.1 a) or b1)] shall be applied.

#### 6.3.3 Tensile test and impact test

**6.3.3.1** Test pieces for tensile tests shall be tested (as far as possible) with their original surface (see figure 1).

**6.3.3.2** Impact test pieces shall be taken in accordance with figure 1 and be prepared in accordance with ISO 83 or ISO 148.

#### 6.3.4 Structure

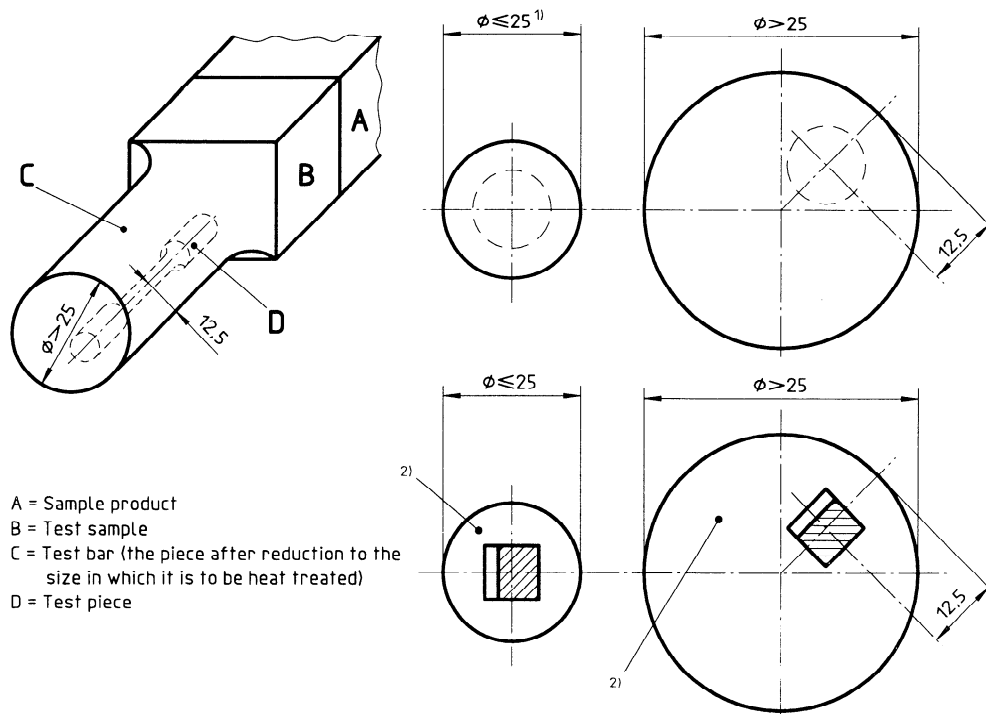
For the selection and preparation of the test pieces for the verification of the austenitic grain size, the indications in ISO 643 apply. In cases of dispute, if not otherwise agreed at the time of enquiry and order, the indications for the McQuaid-Ehn method shall be observed, if case-hardening steels (see clause 7) are to be examined. In cases where steels for quenching and tempering (see clause 8) are to be examined, one of the other methods described in ISO 643 shall be applied and the austenitizing temperature shall correspond to the highest hardening temperature (see table A.3) for the steel type concerned, and this temperature shall be maintained for 1 h.

#### 6.3.5 Internal soundness

For the selection and preparation of the test pieces for the verification of the content of non-metallic inclu-



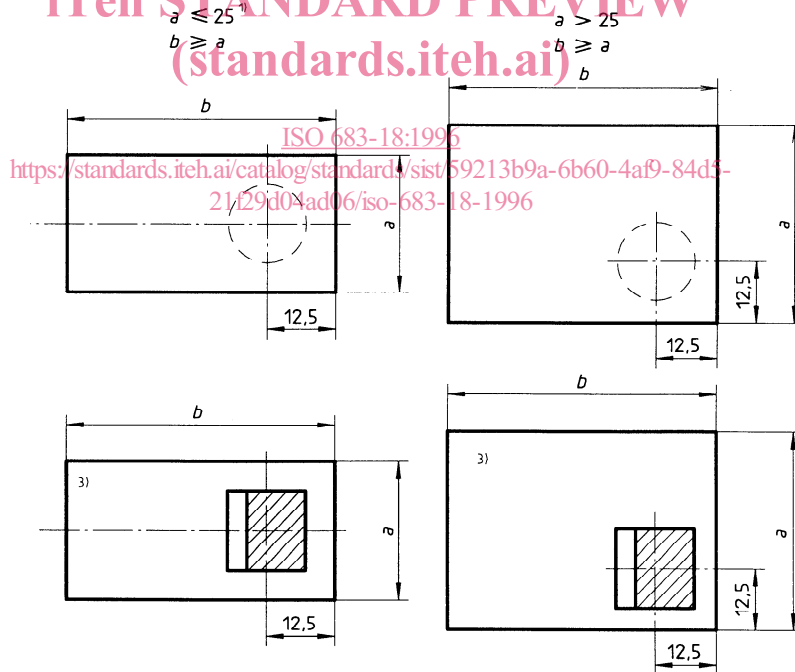
Dimensions in millimetres



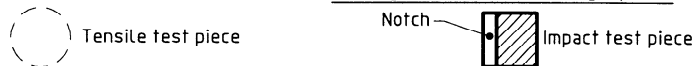
A = Sample product  
 B = Test sample  
 C = Test bar (the piece after reduction to the size in which it is to be heat treated)  
 D = Test piece

Circular and similar shaped sections

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Rectangular sections including squares



- 1) For small products ( $d$  or  $a \leq 25$  mm), the test piece shall, if possible, consist of an unmachined part of the bar.
- 2) For round bars, the direction of the notch axis shall be approximately parallel to the direction of the diameter running through the cross-section of the test piece.
- 3) For rectangular bars, the notch axis shall be perpendicular to the widest rolling surface.

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

sions, the indications in ISO 4967 or other agreed standards apply.

### 6.3.6 Outer soundness

For the verification of surface quality, see ISO 9443.

### 6.3.7 Decarburization

Etched transverse microsections with sharp edges shall be prepared for a microscopic examination of decarburization. However, in cases of dispute, with the exception of products in the cold-drawn condition, the microsection shall be hardened, taking precautions to prevent decarburization or carburization. After hardening, the microsections shall be prepared for microhardness measurements by grinding and polishing. In all cases, the requirements of ISO 3887 shall be observed.

## 6.4 Methods of test

### 6.4.1 Chemical analysis

In the case of dispute about the analytical method, the chemical composition shall be determined in accordance with a reference method specified in ISO standards listed in ISO/TR 9769.

### 6.4.2 Hardenability test

The end-quench hardenability test shall be carried out in accordance with ISO 642. The temperature for quenching shall be in accordance with tables 7, 8, 15, 16 or 17.

### 6.4.3 Tensile test and impact test

**6.4.3.1** The tensile test shall be carried out in accordance with ISO 6892.

**6.4.3.2** The impact test shall be carried in accordance with ISO 83 or ISO 148.

### 6.4.4 Structure

The austenitic grain size shall be tested in accordance with ISO 643 on test pieces prepared in accordance with 6.3.4.

### 6.4.5 Internal soundness

For determining the content of microscopic non-metallic inclusions, the procedure shall be agreed upon at the time of enquiry and order (for example, see ISO 4967).

### 6.4.6 Outer soundness

If, at the time of enquiry and order, an agreement has been reached regarding surface quality classes, the verification shall be in accordance with ISO 9443.

### 6.4.7 Decarburization

When testing the products with regard to their decarburization (see ISO 3887), the depth of the ferritic completely decarburized zone and that of the ferritic-pearlitic partially decarburized zone are usually measured by microscope at a magnification of  $\times 100$ , at the four ends of the diameters of the two etched planes perpendicular to each other. The inner starting point for the measurement of the depth of the ferritic-pearlitic decarburized zone shall be the point at which a marked decrease of the pearlite content begins. (This is usually at about two-thirds of the total depth of the ferritic-pearlitic decarburized zone.) The average of the four single values obtained in this way shall be calculated.

In cases of dispute, with the exception of products in the cold-drawn condition, the decarburization shall be checked by microhardness measurements (HV 0,3) along the two diameters. For the depth of the decarburized zone, the average of the distances  $e_1$ ,  $e_2$ ,  $e_3$  and  $e_4$  (see figure 2) shall be calculated. The single values  $e_1$  to  $e_4$  represent, according to figure 2, the distance between the surface and the next point of the corresponding diameter, where the hardness is 80 % of the maximum hardness which, in the case of decarburization, is measured in the outer zone of the microsection.

## 6.5 Retests

For retests, ISO 404 shall apply.

## 7 Specific requirements for bright products of case-hardening steels

### 7.1 Scope

This clause covers the specific requirements for the bright products of case-hardening steels. It applies for thicknesses up to 160 mm in the case of unalloyed steels and up to 80 mm in the case of alloyed steels.

### 7.2 Requirements

#### 7.2.1 Survey of combinations of usual treatment conditions on delivery and requirements

Table 2 gives a survey of combinations of usual treat-

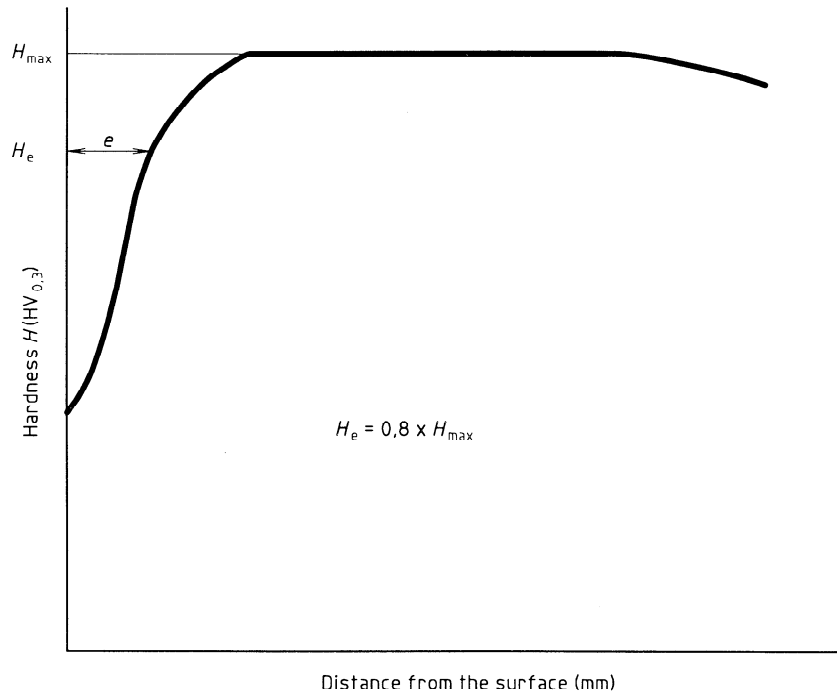


Figure 2 — Determination of the depth of the decarburized zone

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ment conditions, on delivery and requirements concerning chemical composition, mechanical properties and hardenability.

**7.2.2 Chemical composition**

**7.2.2.1** The chemical composition of the steel, determined by the cast analysis, shall be in accordance with the specifications in table 3.

**7.2.2.2** Table 4 gives the permissible deviations between the values given in table 3 and those from the product analysis.

**7.2.3 Hardenability and mechanical properties**

**7.2.3.1** Where the steel is not ordered according to hardenability requirements, i.e. where the steel type designations of tables 3, 5 and 6 are applied, and not the designations given in table 7 or 8 (besides the requirements for chemical composition), the requirements for mechanical properties given in table 2, column 4.2, apply for the particular heat-treatment condition. In this case, the values of hardenability given in table 7 are for guidance only.

**7.2.3.2** Where the steel is, by using the designations given in table 7 or 8, ordered to normal (see table 7) or to narrowed (see table 8) hardenability requirements, the values of hardenability given in table 7 or 8, respectively, apply in addition to the requirements given in table 2, columns 4.1 and 4.2 [see footnote 1) to table 3].

**7.2.4 Treatment condition at the time of delivery**

The steels are usually delivered in one of the treatment conditions listed in table 2.

**7.2.5 Machinability**

All steels are machinable in the conditions “annealed to maximum hardness requirements” and “treated to improve machinability”.

Where improved machinability is required, the grades with a specified sulfur range should be ordered.

**7.2.6 Shearability**

Under suitable shearing conditions (avoiding local stress peaks, preheating, application of blades with a profile adapted to that of the product, etc.) all steels are shearable in the condition “annealed to maximum hardness requirements”.

**Table 2 — Combinations of usual treatment conditions on delivery and requirements for case-hardening steels**

1	2		3	4		5		
1	Treatment condition on delivery <sup>1)</sup>		Symbol	Applicable requirements if the steel is ordered with the designation given in table 3, 5 or 6		Applicable requirements if the steel is ordered with the designation given in table 7 or 8		
				4.1	4.2	5.1	5.2	5.3
2	Cold drawn <sup>2)</sup>		TC	Chemical composition according to tables 3 and 4	In the case of unalloyed steels, mechanical properties according to table 5, column 3; in the case of alloyed steels, maximum tensile strength according to table 6, column 3	As in column 4 [see footnote 1) to table 3]		Hardenability values according to table 7 or 8
3	Peeled <sup>3)</sup>		P		—			
4	Ground		G		—			
5	Cold drawn <sup>2)</sup>	and stress relieved	TC + TSR		The values shall, if necessary, be agreed upon			
6	Peeled <sup>3)</sup>		P + TSR					
7	Ground		G + TSR					
8	Cold drawn <sup>2)</sup>	and annealed to maximum hardness requirements	TC + TA		Maximum hardness according to table 5, column 4, or table 6, column 4			
9	Peeled <sup>3)</sup>		P + TA					
10	Ground		G + TA					
11	Cold drawn <sup>2)</sup>	and treated to improve machinability	TC + M		Hardness range according to table 6, column 5			
12	Peeled <sup>3)</sup>		P + M					
13	Ground		G + M					
14	Treated to improve machinability and cold drawn		M + TC		Hardness range according to table 6, column 6			

1) Other treatment conditions, for example "treated to ferrite-pearlite structure", may be agreed upon at the time of enquiry and order. The condition "annealed to achieve a spheroidization of the carbides", as required for cold heading and cold extrusion, is covered in ISO 4954.

2) For rounds with diameters over 50 mm, it is more usual to apply peeling instead of drawing.

3) Peeling is in general possible for diameters of 16 mm and over.

**Table 3 — Types of case-hardening steel and chemical composition (applicable to cast analysis)**

Elements which are not mentioned should 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 should be taken to prevent the addition, from scrap or other material used during manufacture, of elements which could affect the hardenability, mechanical properties and applicability.

Type of steel <sup>[2) 3) 4)</sup>	Chemical composition [% (m/m)] <sup>1)</sup>							
	C	Si <sup>5)</sup>	Mn	P max.	S	Cr	Mo	Ni
C 10	0,07 to 0,13	0,15 to 0,40	0,30 to 0,60	0,035	0,035 max.	—	—	—
C 15 E4	0,12 to 0,18	0,15 to 0,40	0,30 to 0,60	0,035	0,035 max.	—	—	—
C 15 M2					0,020 to 0,040			
20 Cr 4	0,17 to 0,23	0,15 to 0,40	0,60 to 0,90	0,035	0,035 max.	0,90 to 1,20	—	—
20 CrS 4					0,020 to 0,040			
16 MnCr 5	0,13 to 0,19	0,15 to 0,40	1,00 to 1,30	0,035	0,035 max.	0,80 to 1,10	—	—
16 MnCrS 5					0,020 to 0,040			
20 MnCr 5	0,17 to 0,23	0,15 to 0,40	1,10 to 1,40	0,035	0,035 max.	1,00 to 1,30	—	—
20 MnCrS 5					0,020 to 0,040			
20 NiCrMo 2	0,17 to 0,23	0,15 to 0,40	0,65 to 0,95	0,035	0,035 max.	0,30 to 0,65	0,15 to 0,25	0,40 to 0,70
20 NiCrMoS 2					0,020 to 0,040			
18 CrNiMo 7	0,15 to 0,21	0,15 to 0,40	0,35 to 0,65	0,035	0,035 max.	1,50 to 1,80	0,25 to 0,35	1,40 to 1,70

1) In the case of grades with specified hardenability requirements (see tables 7 and 8), except for phosphorus and sulfur, insignificant deviations from the limits for cast analysis are permissible. These deviations shall, however, not exceed  $\pm 0,01$  % (m/m) in the case of carbon and the values given in table 4 in all other cases.

2) Steels with machinability which has been improved either by the addition of lead or by controlled sulfide morphology may be available on request.

3) Additional case-hardening steels are covered by ISO 683-11:1987.

4) These designations are in accordance with the system proposed in ISO/TR 4949.

5) A lower silicon content may be agreed upon at the time of enquiry and order; in this case, the influence on mechanical properties should be taken into account.