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

Part 7:  
**Bright products of non-alloy and alloy  
steels**

*Aciers pour traitement thermique, aciers alliés et aciers pour  
décolletage —*

*Partie 7: Produits en aciers non alliés et alliés transformés à froid*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at [www.iso.org/patents](http://www.iso.org/patents). ISO shall not be held responsible for identifying any or all such patent rights.

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

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

This first edition of ISO 683-7, together with ISO 16143-4, cancels and replaces ISO 683-18:2014, which has been technically revised.

The main changes are as follows:

- ISO 683-18 was split into ISO 683-7 for non-alloy and alloy steels and into ISO 16143-4 for stainless steels;
- definition for out-of-round was modified with two new definitions on ovality and out-of-shape;
- editorial revision.

A list of all parts in the ISO 683 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

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

## Part 7: Bright products of non-alloy and alloy steels

### 1 Scope

This document specifies the technical delivery requirements for bright steel products in the drawn, peeled/turned or additional ground condition and they are intended for mechanical purposes, for example for machine parts. The bright steel products are subdivided into the following steel types:

- a) non-alloy general engineering steels;
- b) non-alloy free-cutting steels;
- c) non-alloy and alloy case-hardening steels;
- d) non-alloy and alloy steels for quenching and tempering.

Bright products of stainless steels are not part of this document, they are covered by ISO 16143-4.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 286-2, *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes — Part 2: Tables of standard tolerance classes and limit deviations for holes and shafts*

ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

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

ISO 643, *Steels — Micrographic determination of the apparent grain size*

ISO 630-2, *Structural steels — Part 2: Technical delivery conditions for structural steels for general purposes*

ISO 683-1, *Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering*

ISO 683-2, *Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering*

ISO 683-3, *Heat-treatable steels, alloy steels and free-cutting steels — Part 3: Case-hardening steels*

ISO 683-4, *Heat-treatable steels, alloy steels and free-cutting steels — Part 4: Free-cutting steels*

ISO 3887, *Steels — Determination of the depth of decarburization*

ISO 4885, *Ferrous materials — Heat treatments — Vocabulary*

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

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

ISO 4967, *Steel — Determination of content of non-metallic inclusions — Micrographic method using standard diagrams*

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

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 6929, *Steel products — Vocabulary*

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

ISO 14284, *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 4885, ISO 4948-1, ISO 4948-2, ISO 6929, ISO 14284 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1

##### **bright product**

drawn or peeled/turned product with smoother surface quality and better dimensional accuracy in comparison to hot-rolled product

#### 3.2

##### **drawn product**

product of various cross-sectional shapes obtained, after descaling, by cold drawing of hot-rolled product, on a drawing bench (cold formation without removing material)

Note 1 to entry: This operation gives the product special features with respect to shape, dimensional accuracy and surface finish. In addition, the process causes cold working of the product, which can be eliminated by subsequent heat treatment. Products in lengths are delivered straightened, products of small cross-section may also be supplied in coils.

#### 3.3

##### **peeled/turned product**

round bar produced by peeling or turning where the product can be further processed by straightening and polishing

Note 1 to entry: This operation gives the bar special features with respect to shape, dimensional accuracy and surface finish. The removal of metal is carried out in such a way that the bright product is generally free from rolling defects and surface decarburization.

#### 3.4

##### **product in the ground condition**

ground product

drawn or peeled/turned round bar given an improved surface quality and dimensional accuracy by grinding or by grinding and polishing

### 3.5 thickness

nominal dimension of the product

Note 1 to entry: That means:

- a) the diameter in the case of rounds;
- b) the lateral length in the case of squares;
- c) the width over flats in the case of hexagons;
- d) the shorter lateral length in the case of flats (rectangular bars) and wide-flats.

For special sections, 'thickness' shall be defined at the time of enquiry and order.

### 3.6 ovality

difference between the smallest and largest dimension measured across the pairs of opposing points at a common cross-section

### 3.7 out of shape

deviation from the nominal section profile

EXAMPLE Parallelism, perpendicularity and twist.

### 3.8 ruling section

section for which the specified mechanical properties apply

Note 1 to entry: Independent of the actual shape and dimensions of the cross-section of the product, the size of its ruling section is always given by a diameter. This corresponds to the diameter of an "equivalent round bar". That is a round bar which will show the same cooling rate as the actual ruling section of the product concerned at its position for taking the test pieces, when being cooled from austenitizing temperature.

## 4 Classification and designation

### 4.1 Classification

The classification of the relevant steel grades is allocated in accordance with ISO 4948-1 and ISO 4948-2. The general engineering and the free cutting steels are quality steels. The steels for case hardening and for quenching and tempering are special steels.

### 4.2 Designation

For the steel grades covered by this document, the steel names given in the relevant tables are allocated in accordance with ISO/TS 4949.

NOTE Designation of steels covered by this document and of comparable grades covered in various other designation systems are given in [Annex E](#).

## 5 Information to be supplied by the purchaser

### 5.1 Mandatory information

The manufacturer shall obtain the following information from the purchaser at the time of enquiry and order:

- a) quantity (mass, number of bars) to be delivered;

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- b) shape of the product (e. g. round, hexagon, square, flat);
- c) the dimensions and tolerances of the product, see [7.10](#), [Table 3](#) and [Tables 12](#) to [14](#);
- d) a reference to this document, i.e. ISO 683-7:2023;
- e) the designation of the steel grade and the delivery condition (see [Tables 5](#) to [11](#));
- f) standard designation for a test report 2.2 or, if required, any other type of inspection document in accordance with ISO 10474.

### 5.2 Options/Supplementary or special requirements

A number of options are specified in this document and listed below.

- a) reference testing for products used in the quenched and tempered condition (for steels for quenching and tempering only (see [Table 2](#), footnote d and [C.2](#));
- b) any fine grain requirement and verification of fine grain size (see [7.6](#) and [C.3](#));
- c) non-destructive testing (see [7.8](#) and [C.4](#));
- d) the disposition of tolerances in accordance with [7.10](#) and [C.5](#);
- e) bar end conditions may be specified at the time of enquiry and order in accordance with [C.6](#);
- f) product analysis (see [7.2](#), [Table 1](#) and [C.7](#));
- g) for a minimum reduction ratio or minimum thickness deformation (see [6.1](#) and [C.8](#));
- h) temporary corrosion protection (see [6.2.1](#) and [C.9](#));
- i) any requirement to special marking (see [Clauses 10](#) and [C.10](#));
- j) any additionally requirement concerning the surface condition, i.e. ground surface +G or polished surface +PL for round bars (see [6.2.2](#) and [Table 3](#));
- k) surface quality class if another than the standard class is requested (see [7.11](#) and [Table 4](#));
- l) verification of the straightness (see [7.10](#), [Table 15](#), [Table 16](#) and [Annex D](#));
- m) any requirement to the hardenability (+H, +HH, +HL), for special steels only (see [7.4](#));
- n) any requirement for non-metallic inclusions (see [7.7](#));
- o) any requirement regarding the permissible depth of decarburization (see [7.9](#));
- p) impact test at a temperature lower than room temperature (see [9.2.2](#)).

### 5.3 Ordering example

2 t round bars with nominal diameter 20 mm, tolerance h9, stock length 6 000 mm made of steel grade C45 according to this document in delivery condition +C, surface quality class 1 and a test report 2.2 as specified in ISO 10474.

**2 t round bars 20 h9 × stock 6 000**

**steel grade ISO 683-7 - C45+C**

**Inspection document ISO 10474 - 2.2**

## 6 Manufacturing process

### 6.1 General

The manufacturing process of the steel and of the products is with the restrictions given by the requirements in [6.2](#) and [6.3](#) left to the discretion of the manufacturer.

For minimum reduction ratio or minimum thickness deformation ratio of rolled and forged products, see [C.8](#).

### 6.2 Treatment and surface condition at delivery

#### 6.2.1 Treatment condition

The treatment and heat-treatment condition (if any) at the time of delivery shall conform with the condition agreed in the order and shall be one of the conditions indicated in [Table 2](#).

Bright steel products in cold drawn or peeled/turned condition are coated with a light film of grease from processing, for bright steel products in a finally heat-treated condition, the manufacturer chooses the rust protection after heat treatment.

The usual light application of ordinary grease or oil does not afford positive protection against rusting, particularly in the presence of condensation water. The use of a selected rust inhibitor or a special type of packing shall, if required, be agreed at the time of enquiry and order, see [C.9](#).

#### 6.2.2 Surface conditions

The surface condition and the tolerance classes on bright steel products shall conform with [Table 3](#). One of the classes written in brackets can be agreed at the time of enquiry and order if requested by the purchaser.

### 6.3 Traceability of the cast

Each product shall be traceable to the cast, see [Clause 10](#).

## 7 Requirements

### 7.1 General

Combination of usual treatment conditions at the time of delivery and requirements concerning chemical composition and mechanical properties are shown in [Table 2](#).

In addition to this document, the general technical delivery requirements of ISO 404 shall apply.

This document lists the mechanical characteristics for products up to 100 mm in thickness. For dimensions greater 100 mm thickness, mechanical properties shall be agreed between manufacturer and purchaser at the time of enquiry and order.

### 7.2 Chemical composition

The chemical composition of the steels determined by the cast analysis shall conform with ISO 630-2, ISO 683-1, ISO 683-2, ISO 683-3 and ISO 683-4. The grades and the chemical composition of the steels are also listed for information in this document, see Annex A.

Permissible deviations between the limiting values for cast analysis and the values for product analysis are given in the corresponding tables of ISO 630-2, ISO 683-1, ISO 683-2, ISO 683-3 and ISO 683-4. The product analysis shall be carried out when specified at the time of enquiry and order (see [C.7](#)).

If steels for case hardening or for quenching and tempering are ordered with hardenability requirements in accordance with ISO 683-1, ISO 683-2 and ISO 683-3, such hardenability requirements shall be considered as the governing criteria for acceptance. In such cases, the cast analysis may deviate by the values given in ISO 683-1, ISO 683-2 and ISO 683-3.

**WARNING — Due to hazardous effects to health and environmental problems of Pb, it is recommended to use instead steels only with sulfur and other innocuous free-cutting element additions.**

### 7.3 Mechanical properties

For steels ordered in one of the treatment conditions in [Table 2](#), the requirements for mechanical properties specified in [Tables 5 to 11](#) shall apply. The mechanical property values given in [Tables 5 to 11](#) shall apply to test pieces that have been taken and prepared in accordance with [Figure 1](#). By agreement, alternative mechanical properties may be agreed. For bright products in heat treated condition +N, +A, +FP after cold drawing and in the condition +N+SH the requirements of the relevant International Standard, i.e. ISO 630-2, ISO 683-1, ISO 683-2 or ISO 683-3, shall apply.

In this case, the normal and narrowed hardenability values given in ISO 683-1, ISO 683-2 for special steels and the narrowed hardenability values in ISO 683-3 for alloy special steels are for guidance purposes only.

An impact test shall be performed if mentioned in the tables of mechanical properties for the condition +QT+SH/+C+QT. For cold drawn bars (+C, +C+G, +C+PL), an impact test shall not be performed, since there are no reference values unless impact test and Charpy values are agreed at the time of enquiry and order. Additional requirements concerning the impact energy and the verification at temperatures other than room temperature (0 °C, -20 °C and -40 °C) can be agreed at the time of enquiry and order.

NOTE In [Tables 5 to 11](#), grades alloyed with further elements for better machinability are not explicitly mentioned, but the mechanical properties are also valid for them (see [Tables A.1 to A.4](#)).

### 7.4 Hardenability

Unless otherwise agreed for alloy case-hardening steels, the normal hardenability requirements given in ISO 683-3 shall apply. If agreed at the time of enquiry and order, alloy case-hardening steels with restricted hardenability scatterbands given in ISO 683-3 shall be supplied and these values shall apply in addition to [Table 2](#), columns 6 and 7. By agreement, alternative hardenability may be agreed.

If special steels for quenching and tempering are ordered by using the designations to normal or to narrowed hardenability scatterbands, the values of hardenability given in ISO 683-1 or ISO 683-2 shall apply in addition to [Table 2](#), columns 8 and 9.

NOTE In [Tables 9 to 11](#), grades alloyed with further elements for better machinability are not explicitly mentioned, but the mechanical properties are also valid for them (see [Tables A.3 and A.4](#)).

### 7.5 Machinability

Depending on the steel grade, machinability is possible in the condition cold drawn (+C), treated to ferrite/pearlite structure (+FP), normalized (+N) or soft annealed (+A). After machining, small changes in the shape may occur. Stress relieving' (+SR) will reduce these effects.

If improved machinability is required, grades with defined ranges of alloying elements, which support the machinability and/or with a specific treatment to improve machinability should be ordered (see also footnote b in [Tables A.1, A.3 and A.4](#)).

Free-cutting steels with low carbon content have their best machinability in the cold drawn condition.

NOTE Non-leaded steels with comparable chemical composition generally have identical mechanical properties but often lower machinability than leaded steels.

## 7.6 Grain size

Unless otherwise agreed at the time of enquiry and order the grain size of the general engineering, free-cutting steels and the non-alloy steels for quenching and tempering shall be left to the discretion of the manufacturer. If a fine grain structure is required for non-alloy steels for quenching and tempering or for case-hardening or quenched and tempered free-cutting steels, [Annex C](#), the requirement in [C.3](#) shall be ordered.

If direct hardening treatment is used for free-cutting case-hardening steels, a fine grain structure should be ordered.

The case-hardening and the alloy steels for quenching and tempering shall have a fine grain structure with an austenite grain size of 5 or finer when tested in accordance with ISO 643. See [C.3](#) for verification only.

## 7.7 Non-metallic inclusions

### 7.7.1 Microscopic inclusions

The special steels shall have a certain degree of cleanliness, however, verification of the non-metallic inclusion content requires a special agreement. If there is such an agreement at the time of enquiry and order, the microscopically non-metallic inclusion content shall be determined to an agreed procedure and within agreed limits according to ISO 4967 or another regional standard, e.g. EN 10247 or JIS G 0555.

For grades with specified minimum sulfur content, the agreement should only concern the oxides.

### 7.7.2 Macroscopic inclusions

Freedom of macroscopic inclusions cannot be ensured in any steel. This requirement is applicable for the verification of the macroscopic inclusions in special steels. If verification is agreed, then the method and acceptance limits shall be agreed at the time of enquiry and order.

## 7.8 Internal soundness

Requirements relating to the internal soundness of the products may be agreed at the time of enquiry and order, see [C.4](#).

## 7.9 Decarburization

For steels for quenching and tempering, requirements relating to the permissible depth of decarburization may be agreed at the time of enquiry and order.

The depth of decarburization shall be determined in accordance with the micrographic method specified in ISO 3887.

## 7.10 Shape, dimensions and tolerances

The tolerance class on thickness (and width for flats) shall conform with the requirements agreed at the time of enquiry and order and shall be in accordance with [Table 3](#). If there is no agreement on the tolerance class, the bright products are delivered with the standard tolerance class given in [Table 3](#). The tolerance class and the corresponding tolerances are given in [Table 12](#) for rounds, squares and hexagons and in [Table 13](#) for drawn flats. Where specified by the purchaser at the time of enquiry and order, the disposition tolerances specified in [Table 12](#) shall be in accordance with [C.5](#).

Unless otherwise agreed at the time of enquiry and order, the length and the tolerance on length shall be as specified in [Table 14](#).

Maximum deviation from 'ovality' shall be not more than half the specified tolerance range and in any case never above the upper limit of the tolerance. Any requirements concerning out of shape may be agreed at the time of enquiry and order together with the measurement method.

For the evaluation of straightness, automatic methods can be used at the discretion of the manufacturer. Where specified at the time of enquiry and order and in cases of dispute, an agreed number of bars shall be evaluated for straightness in accordance with one of the methods specified in [Annex D](#). The tolerances specified in [Tables 15](#) and [16](#) shall apply.

Non-round bars (i.e. square, hexagon and flat) in widths  $\leq 150$  mm may have an undefined profile within a distance of 0,2 mm of the hypothetical edge, flats in widths  $>150$  mm within a distance of 0,5 mm of the hypothetical edge, unless otherwise agreed. For widths  $>150$  mm sharp corners can specifically be ordered.

### 7.11 Surface quality

Bright products shall have a smooth, scale free surface. Bright products in the final heat-treated condition shall be free from loose surface scale; their surface might be discoloured or darker. For hexagons, squares, flats and profiles with special cross-sections, one cannot achieve – for manufacturing reasons – the same quality of surface finish as for round cross-sections.

Since surface discontinuities (cracks, overlapping, scale, isolated pores, pits, grooves, etc.) cannot be completely avoided during manufacturing (hot and cold forming, heat treatments, handling and storage) and since they are retained when drawing, agreements shall be made regarding surface quality. The surface quality of the products shall be one of the classes in accordance with [Table 4](#). Cold drawn bars are normally delivered in class 1, while peeled/turned bars as well as ground/polished bars are delivered in class 3. Different classes may be agreed at the time of enquiry and order.

For flats, squares in sizes greater than 20 mm and hexagons in sizes greater than 50 mm, the maximum possible depth of surface discontinuities shall be agreed at the time of enquiry and order.

NOTE Where automatic testing of the surface is applied, 50 mm of each end of the bar is not normally covered.

Surface defects cannot be eliminated without removal of material. Products in the 'technically crack free by manufacture' condition are only available in the peeled/turned and/or ground conditions.

## 8 Inspection

### 8.1 Testing procedures and types of documents

**8.1.1** Products conforming with this document shall be ordered and delivered with one of the inspection documents specified in ISO 10474. The type of document shall be agreed upon at the time of enquiry and order. If the order does not contain any specification of this type, a test report 2.2 shall be issued.

**8.1.2** If, in accordance with the agreements made at the time of enquiry and order, a test report 2.2 must be provided, this shall cover the following information:

- a) confirmation that the material conforms with the requirements of the order;
- b) results of the cast analysis for all elements specified for the steel type concerned.

**8.1.3** If, in accordance with the agreements made at the time of enquiry and order, an inspection certificate 3.1 or 3.2 in accordance with ISO 10474 must be provided, the specific inspections and tests

described in [8.3](#) and [Clause 9](#) shall be carried out and the results shall be confirmed in the inspection certificate.

In addition, the inspection certificate shall cover:

- a) confirmation that the material conforms with the requirements of the order;
- b) results of the cast analysis for all elements specified for the steel type concerned;
- c) the result of all inspections and tests ordered by supplementary requirements (see [Annex C](#));
- d) the symbol letters or numbers relating the inspection certificate, test pieces and products to each other.

## 8.2 Frequency of testing

The amount of testing, the sampling conditions and the test methods to be applied for the verification of the requirements shall be in accordance with the prescriptions of [Table 1](#).

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**Table 1 — Test conditions for the verification of the requirements given in Tables 5 to 11**

No.	Requirements	Test unit <sup>a</sup>	Amount of testing		Sampling and sample preparation	Test method to be used
			Number of <sup>b</sup>			
			samples per test unit	tests per sample		
1	Chemical composition	C	The cast analysis is given by the manufacturer (m); for product analysis see C.7 (o)		ISO 14284	See list in ISO/TR 9769 <sup>c</sup>
2	Mechanical properties				ISO 377	Tensile test <sup>d</sup> ISO 6892-1  Impact test ISO 148-1
2.1	As-rolled and peeled	C+D	1	1 tensile (m)		
2.2	Cold drawn	C+D	1	1 tensile (m)		
2.3	'Quenched and tempered and peeled' or 'Cold drawn and quenched and tempered'	C+D+T	1	1 tensile (m) and 3 CVN <sup>f</sup> (m)		
2.4	Quenched and tempered and cold drawn	C+D+T	1	1 tensile (m)		
3	Hardness <sup>e</sup>				ISO 6506-1	Brinell hardness test ISO 6506-1
3.1	As-rolled and peeled	C+D	1	1 (m)		
3.2	Heat-treated and peeled	C+D+T	1	1 (m)		
3.3	Heat-treated and cold drawn	C+D+T	1	1 (m)		

Verification of the requirements is only necessary if an inspection certificate is ordered.

<sup>a</sup> The tests shall be carried out separately for each cast as indicated by 'C', each dimension as indicated by 'D', and each heat-treatment batch as indicated by 'T'. Products with different thickness may be grouped if the differences in thickness do not affect the properties.

<sup>b</sup> Tests marked with an "m" (mandatory) shall be carried out as specific tests. In all cases, those marked with an "o" (optional) shall be carried out as specific tests only if agreed at ordering.

<sup>c</sup> For routine testing also other methods are available (e.g. spectrographic).

<sup>d</sup> In cases of dispute, the tensile test shall be carried out on proportional test pieces having a gauge length of  $L_0 = 5,65 \sqrt{S_0}$ , where  $S_0$  is the original cross-section area.

<sup>e</sup> Unless otherwise agreed at the order, the manufacturer decides whether to use the tensile test or hardness test. In the case of dispute the tensile test shall be performed. If in the case of case hardening steels only hardness values are available, the hardness test shall be performed on the cross section at the same point as specified for the centre line of the tensile test piece.

<sup>f</sup> For nominal thickness  $\geq 16$  mm standard test pieces 10 mm x 10 mm shall be machined. For thicknesses  $< 16$  mm the test shall only be performed if test pieces with reduced widths and Charpy-V-notch (CVN) values are agreed at the time of enquiry and order.

### 8.3 Specific inspection and testing

#### 8.3.1 Verification of the hardenability, hardness and mechanical properties

For steels ordered in one of the treatment conditions in Table 2, the hardness requirements or mechanical properties, shall be verified with the following exception. The requirements given in Table 2, footnote c (mechanical properties of reference test pieces), shall only be verified if the supplementary requirement specified in C.2 is ordered.

For steels being ordered with the symbol +H, +HH or +HL in the designation, unless otherwise agreed, only the hardenability requirements in accordance with ISO 683-1, ISO 683-2 and ISO 683-3 shall be verified.

### 8.3.2 Visual and dimensional inspection

A sufficient number of products shall be inspected to ensure the conformity with the specification.

Dimensional inspection shall be carried out as follows:

- a) for bars in manufacturing or stock length: not less than 150 mm from the end of the bar;
- b) for bars cut to length: not less than 10 mm from the end of the bar.

If agreed at the time of enquiry and order, dimensional inspection shall be performed for bars in manufacturing or stock length for nominal diameter >100 mm, not less than 250 mm from both ends of the bar.

## 9 Test methods

### 9.1 Chemical analysis

The choice of a suitable physical or chemical analytical method for the analysis shall be at the discretion of the manufacturer. In cases of dispute, the method for product analysis used shall be agreed taking into account the relevant existing International Standards.

The list of available International Standards on chemical analysis is given in ISO/TR 9769.

### 9.2 Mechanical tests

#### 9.2.1 Tensile test

The tensile test shall be carried out in accordance with ISO 6892-1.

For the specified yield strength in the tables on mechanical properties in this document, the upper yield strength ( $R_{eH}$ ) shall be determined.

If a yield phenomenon is not present, the 0,2 % proof strength ( $R_{p0,2}$ ) shall be determined.

#### 9.2.2 Impact test

The Charpy-V-notch (CVN) impact test shall be carried out in accordance with ISO 148-1.

The average values of a set of three test pieces shall be equal to or greater than the specified value. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

If these conditions are not satisfied additional tests can be done according to ISO 404 on the assessment of results of sequential tests.

### 9.3 Hardness and hardenability tests

#### 9.3.1 Hardness in treatment conditions +A and +FP

For products in treatment conditions +SH (hot-rolled and peeled/turned), +A+SH (soft annealed and peeled/turned), +A+C (soft annealed and cold drawn), +FP +SH (treated to ferrite-pearlite structure and peeled/turned) and +FP+C (treated to ferrite-pearlite structure and cold drawn), the hardness tests shall be carried out in accordance with ISO 6506-1.

### 9.3.2 Verification of hardenability

The verification of hardenability shall be in accordance with ISO 683-1, ISO 683-2 and ISO 683-3.

### 9.4 Verification of dimensions

The ovality shall be carried out by the two-point measuring method. Other methods shall be agreed at the time of enquiry and order.

### 9.5 Retests

Retests and criteria should be as specified in ISO 404.

## 10 Marking

The manufacturer shall mark the products or the bundles or boxes containing the products in a suitable way, so that the identification of the cast, the steel type and the origin of the delivery is possible (see [C.10](#)).

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Table 2 — Combinations of usual treatment conditions at delivery and requirements for bright steels

1	2	3	4	5	6	7	8	9
Treatment condition at delivery	Symbol	Chemical composition	General engineering steels	Free cutting steels	Non-alloy case-hardening steels	Alloy case-hardening steels	Non-alloy steels for quenching and tempering	Alloy steels for quenching and tempering
As-rolled and peeled/turned <sup>a</sup>	+SH	All steels	See <a href="#">Table 5</a>	See <a href="#">Table 6, 7</a>	See <a href="#">Table 8</a>	-	See <a href="#">Table 10<sup>c</sup></a>	-
Cold drawn	+C		See <a href="#">Table 5<sup>b</sup></a>	See <a href="#">Table 6, 7</a>	See <a href="#">Table 8</a>	-	See <a href="#">Table 10<sup>c</sup></a>	-
Soft annealed and peeled/turned	+A+SH		-	-	See <a href="#">Table 8</a>	See <a href="#">Table 9</a>	See <a href="#">Table 11<sup>c</sup></a>	-
Soft annealed and cold drawn	+A+C		-	-	See <a href="#">Table 8</a>	See <a href="#">Table 9</a>	See <a href="#">Table 11<sup>c</sup></a>	-
Treated to ferrite-pearlite structure and hardness range and peeled/turned	+FP+SH		Chemical composition according to	-	-	-	See <a href="#">Table 9</a>	-
Treated to ferrite-pearlite structure and hardness range and cold drawn	+FP+C	ISO 630-2, ISO 683-1,	-	-	-	See <a href="#">Table 9</a>	-	

<sup>a</sup> Peeling is in general possible for diameters of 16 mm and over.

<sup>b</sup> If these steels should be drawn and quenched and tempered, values for this treatment could be found at the comparable special steel grades in [Table 10](#).

<sup>c</sup> The mechanical properties specified in [Table 10](#), and in [Table 11](#) for the condition +C+QT must be achievable after appropriate heat treatment if so agreed in the order (for reference test pieces see [C.2](#)).

Table 2 (continued)

1	Treatment condition at delivery	1	2	3	4	5	6			8	9
							General engineering steels	Free cutting steels	Non-alloy case-hardening steels		
8	'Quenched and tempered and peeled' or 'cold drawn and quenched and tempered'	All steels	+QT+SH +C+QT	ISO 683-2, ISO 683-3, and ISO 683-4, see <a href="#">Tables A.1 to A.4</a>	- <sup>b</sup>	See <a href="#">Table 7</a>	-	-	See <a href="#">Table 10</a>	See <a href="#">Table 11</a>	
9	Quenched+tempered and cold drawn		+QT+C		-	See <a href="#">Table 7</a>	-	-	See <a href="#">Table 10</a>	See <a href="#">Table 11</a>	
10	Other heat-treatment conditions, for example, stress relieved (+SR), normalized (+N), cold drawn and annealed or normalized (+C+A, +C+N) and the mechanical properties, may be agreed 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.									To be agreed	

<sup>a</sup> Peeling is in general possible for diameters of 16 mm and over.

<sup>b</sup> If these steels should be drawn and quenched and tempered, values for this treatment could be found at the comparable special steel grades in [Table 10](#).

<sup>c</sup> The mechanical properties specified in [Table 10](#), and in [Table 11](#) for the condition +C+QT must be achievable after appropriate heat treatment if so agreed in the order (for reference test pieces see [C.2](#)).

Table 3 — Surface condition and tolerance class at delivery

	1	2	3	4	5	6	7	8
1	Surface condition at delivery	Symbol	Tolerance class to ISO 286-2 <sup>a</sup>					Notes
			Rounds	Squares	Hexagons	Drawn flats	Special sections	
2	Cold drawn or heat-treated and cold drawn	+C	h10 (h9 to h12) in <a href="#">Table 12</a>	h11 for $d \leq 80$ mm, h12 for $d > 80$ mm <sup>c</sup> (h11 or h12); in <a href="#">Table 12</a>		h11, h12, in <a href="#">Table 13</a>	– <sup>b</sup>	See <a href="#">Table 2</a> , lines 3,5,7,9
3	Cold drawn, heat treated	+C+QT (+C+N) (+C+SR) (+C+A)	h11 in <a href="#">Table 12</a>	– <sup>b</sup>	– <sup>b</sup>	–	–	Finish for good ductility see <a href="#">Table 2</a> , line 8
4	Peeled/turned	+SH	h10 (h9 to h12) in <a href="#">Table 12</a>	–	–	–	–	See <a href="#">Table 2</a> , lines 2,4,6
5	Ground	+G	h9 (h6 to h10) in <a href="#">Table 12</a>	–	–	–	–	Obtained, e.g. from conditions <a href="#">Table 2</a> , lines 2 to 7 and 9
6	Polished	+PL	h9 (h6 to h12) in <a href="#">Table 12</a>	–	–	–	–	Obtained, e.g. from conditions <a href="#">Table 2</a> , lines 2 to 7 and 9

<sup>a</sup> Standard tolerance classes unless otherwise specified. In brackets: other possible tolerance classes according to ISO 286-2 if required at the time of enquiry and order.

<sup>b</sup> To be agreed at the time of enquiry and order.

<sup>c</sup> If squares above 100 mm thickness are agreed, the tolerance class shall be js15 in accordance with ISO 286-2.

Table 4 — Surface quality classes

Condition	Class			
	1	2	3	4
Permissible depth of discontinuities	max. 0,3 mm for $t \leq 15$ mm; max. 0,02t for $15 < t \leq 100$ mm	max. 0,3 mm for $t \leq 15$ mm; max. 0,02t for $15 < t \leq 75$ mm; max. 1,5 mm for $t > 75$ mm	max. 0,2 mm for $t \leq 20$ mm; max. 0,01t for $20 < t \leq 75$ mm; max. 0,75 mm for $t > 75$ mm	technically crack free by manufacturer <sup>e</sup>
Maximum percentage of delivered weight with discontinuities in excess of specified level	4 %	1 %	1 %	0,2 %
Product form <sup>a</sup>				
Rounds	+	+	+	+
Squares	+	+(for $t \leq 20$ mm) <sup>c</sup>	-	-
Hexagons	+	+(for $t \leq 50$ mm) <sup>c</sup>	-	-
Flats	+ <sup>b</sup>	-	-	-
Special sections	+ <sup>d</sup>	-	-	-
<p><math>t</math> = nominal thickness that means diameter of round bars and distance across flats of squares and hexagons</p> <p><sup>a</sup> + indicates available in these classes, - indicates not commonly available in these classes.</p> <p><sup>b</sup> Maximum depth of discontinuities refers to respective section (width or thickness).</p> <p><sup>c</sup> Crack detection with eddy current device not possible for <math>t &gt; 20</math> mm or <math>t &gt; 50</math> mm as indicated.</p> <p><sup>d</sup> Reference dimensions to be agreed at the time of enquiry and order.</p> <p><sup>e</sup> The surface quality class shall be better than class 3. The requirements and the kind of verification shall be agreed at the time of enquiry and order.</p>				

Table 5 — Mechanical properties of bright steels for general engineering use

Steel name	Thickness <sup>a</sup> <i>t</i> mm	Mechanical properties <sup>a</sup>				
		As-rolled + peeled (+SH)		Cold drawn (+C)		
		Hardness <sup>b</sup> HBW	$R_m$ MPa	$R_{p0,2}$ <sup>c</sup> MPa min.	$R_m$ <sup>c</sup> MPa	A % min.
S235B	$5 \leq t \leq 10$	-	-	355	470 to 840	8
	$10 < t \leq 16$	-	-	300	420 to 770	9
	$16 < t \leq 40$	107 to 152	360 to 510	260	390 to 730	10
	$40 < t \leq 63$	107 to 152	360 to 510	235	380 to 670	11
	$63 < t \leq 100$	107 to 152	360 to 510	215	360 to 640	11
S355D	$5 \leq t \leq 10$	-	-	520	630 to 950	6
	$10 < t \leq 16$	-	-	450	580 to 880	7
	$16 < t \leq 40$	140 to 187	470 to 630	350	530 to 850	8
	$40 < t \leq 63$	140 to 187	470 to 630	335	500 to 770	9
	$63 < t \leq 100$	140 to 187	470 to 630	315	470 to 740	9
C25	$5 \leq t \leq 10$	-	-	420	560 to 860	6
	$10 < t \leq 16$	-	-	380	530 to 830	7
	$16 < t \leq 40$	131 to 187	440 to 640	300	510 to 810	8
	$40 < t \leq 63$	131 to 187	440 to 640	265	490 to 790	9
	$63 < t \leq 100$	131 to 187	440 to 640	245	440 to 740	10
C30	$5 \leq t \leq 10$	-	-	455	610 to 910	6
	$10 < t \leq 16$	-	-	420	570 to 870	7
	$16 < t \leq 40$	143 to 198	480 to 680	345	550 to 850	8
	$40 < t \leq 63$	143 to 198	480 to 680	300	520 to 820	9
	$63 < t \leq 100$	143 to 198	480 to 680	250	480 to 780	9
C35	$5 \leq t \leq 10$	-	-	510	650 to 1 000	6
	$10 < t \leq 16$	-	-	420	600 to 950	7
	$16 < t \leq 40$	156 to 204	520 to 700	320	580 to 880	8
	$40 < t \leq 63$	156 to 204	520 to 700	300	550 to 840	9
	$63 < t \leq 100$	156 to 204	520 to 700	270	520 to 800	9
C40	$5 \leq t \leq 10$	-	-	540	700 to 1 000	6
	$10 < t \leq 16$	-	-	460	650 to 980	7
	$16 < t \leq 40$	164 to 207	550 to 710	365	620 to 920	8
	$40 < t \leq 63$	164 to 207	550 to 710	330	590 to 840	9
	$63 < t \leq 100$	164 to 207	550 to 710	290	550 to 820	9

<sup>a</sup> For thickness <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>b</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>c</sup> For flats and special sections, the proof strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) by ±10 %.

<sup>d</sup> Steels C50 and C60 in delivery condition +C may be delivered with additional soft annealing before cold drawing (+A+C), nevertheless mechanical properties are as mentioned in [Table 5](#).

**Table 5 (continued)**

Steel name	Thickness <sup>a</sup> <i>t</i> mm	Mechanical properties <sup>a</sup>				
		As-rolled + peeled (+SH)		Cold drawn (+C)		
		Hardness <sup>b</sup> HBW	<i>R<sub>m</sub></i> MPa	<i>R<sub>p0,2</sub></i> <sup>c</sup> MPa min.	<i>R<sub>m</sub></i> <sup>c</sup> MPa	<i>A</i> % min.
C45	5 ≤ <i>t</i> ≤ 10	-	-	565	750 to 1 050	5
	10 < <i>t</i> ≤ 16	-	-	500	710 to 1 030	6
	16 < <i>t</i> ≤ 40	172 to 241	580 to 820	410	650 to 1 000	7
	40 < <i>t</i> ≤ 63	172 to 241	580 to 820	360	630 to 900	8
	63 < <i>t</i> ≤ 100	172 to 241	580 to 820	310	580 to 850	8
C50 <sup>d</sup>	5 ≤ <i>t</i> ≤ 10	-	-	590	770 to 1 100	5
	10 < <i>t</i> ≤ 16	-	-	520	730 to 1 080	6
	16 < <i>t</i> ≤ 40	179 to 269	610 to 910	440	690 to 1 050	7
	40 < <i>t</i> ≤ 63	179 to 269	610 to 910	390	650 to 1 030	8
	63 < <i>t</i> ≤ 100	179 to 269	610 to 910	-	-	-
C60 <sup>d</sup>	5 ≤ <i>t</i> ≤ 10	-	-	630	800 to 1 150	5
	10 < <i>t</i> ≤ 16	-	-	550	780 to 1 130	5
	16 < <i>t</i> ≤ 40	196 to 278	670 to 940	480	730 to 1 100	6
	40 < <i>t</i> ≤ 63	196 to 278	670 to 940	-	-	-
	63 < <i>t</i> ≤ 100	196 to 278	670 to 940	-	-	-

<sup>a</sup> For thickness <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>b</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>c</sup> For flats and special sections, the proof strength (*R<sub>p0,2</sub>*) may deviate by -10 % and the tensile strength (*R<sub>m</sub>*) by ±10 %.

<sup>d</sup> Steels C50 and C60 in delivery condition +C may be delivered with additional soft annealing before cold drawing (+A+C), nevertheless mechanical properties are as mentioned in [Table 5](#).

**Table 6 — Mechanical properties of free-cutting bright steels (except steels for quenching and tempering)**

Steel name	Thickness <sup>a</sup> <i>t</i> mm	Mechanical properties				
		As-rolled + peeled (+SH) Hardness <sup>b</sup> HBW max.	<i>R<sub>m</sub></i> MPa	<i>R<sub>p0,2</sub></i> <sup>c</sup> MPa min.	<i>R<sub>m</sub></i> <sup>c</sup> MPa	<i>A</i> % min.
Steels not intended for heat treatment						
9S20	$t \leq 16$	154	330 to 520	-	-	-
	$16 < t \leq 40$	154	330 to 520	-	-	-
	$40 < t \leq 63$	154	320 to 520	-	-	-
	$63 < t \leq 100$	140	310 to 470	-	-	-
11SMn30 11SMnPb30 11SMn37 11SMnPb37	$5 \leq t \leq 10$	-	-	440	510 to 810	6
	$10 < t \leq 16$	-	-	410	490 to 760	7
	$16 < t \leq 40$	169	380 to 570	375	460 to 710	8
	$40 < t \leq 63$	169	370 to 570	305	400 to 650	9
	$63 < t \leq 100$	154	360 to 520	245	360 to 630	9
Case-hardening steels						
10S20 10SPb20	$5 \leq t \leq 10$	-	-	410	520 to 780	7
	$10 < t \leq 16$	-	-	390	490 to 740	8
	$16 < t \leq 40$	156	360 to 530	360	460 to 720	9
	$40 < t \leq 63$	156	360 to 530	295	410 to 660	10
	$63 < t \leq 100$	146	350 to 490	235	380 to 630	11
15SMn13	$5 \leq t \leq 10$	-	-	450	560 to 840	6
	$10 < t \leq 16$	-	-	430	500 to 800	7
	$16 < t \leq 40$	178	430 to 600	390	470 to 770	8
	$40 < t \leq 63$	172	430 to 580	350	460 to 680	9
	$63 < t \leq 100$	160	420 to 540	265	440 to 650	10
17SMn20	$5 \leq t \leq 10$	-	-	450	560 to 840	6
	$10 < t \leq 16$	-	-	430	500 to 800	7
	$16 < t \leq 40$	178	430 to 600	390	470 to 770	8
	$40 < t \leq 63$	172	430 to 580	350	460 to 680	9
	$63 < t \leq 100$	160	420 to 540	265	440 to 650	10
<sup>a</sup> For thickness <5 mm, the mechanical properties may be agreed at the time of enquiry and order. <sup>b</sup> In case of dispute, the tensile strength values are the decisive factor. <sup>c</sup> For flats and special sections, the proof strength ( <i>R<sub>p0,2</sub></i> ) may deviate by -10 % and the tensile strength ( <i>R<sub>m</sub></i> ) by ±10 %.						

Table 7 — Mechanical properties of free-cutting bright steels for quenching and tempering

Steel name	Thickness <sup>a,b</sup> <i>t</i> mm	Mechanical properties											
		As-rolled + peeled (+SH)			Cold drawn (+C)			Quenched and tempered and peeled <sup>c</sup> (+QT+SH)			Quenched and tempered + cold drawn (+QT+C)		
		Hardness <sup>d</sup> HBW max.	$R_m$ MPa	$R_{p0,2}$ MPa min.	$R_m$ MPa	$R_{p0,2}$ MPa min.	A % min.	$R_m$ MPa	$R_{p0,2}$ MPa min.	A % min.	$R_m$ MPa	$R_{p0,2}$ MPa min.	A % min.
35S20 35SPb20	5 ≤ <i>t</i> ≤ 10	-	-	480	640 to 880	6	430	630 to 780	-	490	700 to 900	9	
	10 < <i>t</i> ≤ 16	-	-	400	590 to 830	7	430	630 to 780	-	490	700 to 900	11	
	16 < <i>t</i> ≤ 40	198	520 to 680	360	560 to 800	8	380	600 to 750	16	455	650 to 850	12	
	40 < <i>t</i> ≤ 63	196	520 to 670	340	530 to 760	9	320	550 to 700	17	400	570 to 770	13	
36SMn14 36SMnPb14	63 < <i>t</i> ≤ 100	190	500 to 650	300	510 to 680	9	320	550 to 700	17	385	550 to 750	14	
	5 ≤ <i>t</i> ≤ 10	-	-	500	660 to 960	6	480	700 to 850	-	525	750 to 1 000	6	
	10 < <i>t</i> ≤ 16	-	-	440	620 to 920	6	460	700 to 850	-	520	740 to 990	6	
	16 < <i>t</i> ≤ 40	219	560 to 750	390	600 to 900	7	420	670 to 820	15	505	720 to 970	8	
35SMn20 35SMnPb20	40 < <i>t</i> ≤ 63	216	560 to 740	360	580 to 840	8	400	640 to 790	16	475	680 to 930	9	
	63 < <i>t</i> ≤ 100	216	550 to 740	340	560 to 820	9	360	570 to 720	17	405	580 to 840	9	
	5 ≤ <i>t</i> ≤ 10	-	-	500	660 to 960	6	-	-	-	595	850 to 1 000	9	
	10 < <i>t</i> ≤ 16	-	-	440	620 to 920	6	420	620 to 820	14	545	775 to 925	10	
35SMnPb20	16 < <i>t</i> ≤ 40	219	560 to 750	390	600 to 900	7	365	590 to 790	15	490	700 to 900	12	
	40 < <i>t</i> ≤ 63	216	560 to 740	360	580 to 840	8	335	540 to 740	16	490	700 to 900	13	
	63 < <i>t</i> ≤ 100	216	550 to 740	340	560 to 820	9	-	-	16	440	625 to 850	14	

<sup>a</sup> For non-round products in the quenched and tempered conditions, see Figure B.1.

<sup>b</sup> For thickness <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> These values are also valid for the “cold drawn and quenched and tempered condition” (+C+QT).

<sup>d</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>e</sup> For flats and special sections, the proof strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) by ±10 %.

Table 7 (continued)

Steel name	Thickness- s <sup>a,b</sup> t mm	Mechanical properties											
		As-rolled + peeled (+SH)			Cold drawn (+C)			Quenched and tempered and peeled <sup>c</sup> (+QT+SH)			Quenched and tempered + cold drawn (+QT+C)		
		Hardness <sup>d</sup> HBW max.	R <sub>m</sub> MPa	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> <sup>e</sup> MPa	A % min.	
38SMn28 38SMnPb28	5 ≤ t ≤ 10	-	-	550	700 to 960	6	480	700 to 850	-	595	850 to 1 000	9	
	10 < t ≤ 16	-	-	500	660 to 960	6	460	700 to 850	-	595	850 to 1 000	9	
	16 < t ≤ 40	213	560 to 730	420	610 to 900	7	420	700 to 850	16	490	700 to 900	11	
	40 < t ≤ 63	213	560 to 730	400	600 to 840	7	400	700 to 850	16	490	700 to 900	12	
44SMn28 44SMnPb28	63 < t ≤ 100	204	550 to 700	350	580 to 820	8	380	630 to 800	16	490	700 to 900	12	
	5 ≤ t ≤ 10	-	-	600	760 to 1 030	5	520	700 to 850	-	595	850 to 1 000	9	
	10 < t ≤ 16	-	-	530	710 to 980	5	480	700 to 850	-	595	850 to 1 000	9	
	16 < t ≤ 40	241	630 to 820	460	660 to 900	6	420	700 to 850	16	490	700 to 900	11	
	40 < t ≤ 63	231	620 to 790	430	650 to 870	7	410	700 to 850	16	490	700 to 900	12	
	63 < t ≤ 100	228	610 to 780	390	630 to 840	7	400	700 to 850	16	490	700 to 900	12	

<sup>a</sup> For non-round products in the quenched and tempered conditions, see Figure B.1.

<sup>b</sup> For thickness <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> These values are also valid for the “cold drawn and quenched and tempered condition” (+C+QT).

<sup>d</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>e</sup> For flats and special sections, the proof strength (R<sub>p0,2</sub>) may deviate by -10 % and the tensile strength (R<sub>m</sub>) by ±10 %.

Table 7 (continued)

Steel name	Thickness- $s^{a,b}$ $t$ mm	Mechanical properties										
		As-rolled + peeled (+SH)		Cold drawn (+C)			Quenched and tempered and peeled <sup>c</sup> (+QT+SH)			Quenched and tempered + cold drawn (+QT+C)		
		Hardness <sup>d</sup> HBW max.	$R_m$ MPa	$R_{p0,2}$ MPa min.	$R_m$ MPa	$A$ % min.	$R_{p0,2}$ MPa min.	$R_m$ MPa	$A$ % min.	$R_{p0,2}^e$ MPa min.	$R_m^e$ MPa	$A$ % min.
46S20 46SPb20	5 ≤ t ≤ 10	-	-	570	740 to 980	5	490	700 to 850	-	595	850 to 1 000	8
	10 < t ≤ 16	-	-	470	690 to 930	6	490	700 to 850	-	560	800 to 950	9
	16 < t ≤ 40	222	590 to 760	400	640 to 880	7	430	650 to 800	13	490	700 to 850	10
	40 < t ≤ 63	213	580 to 730	380	610 to 850	8	370	630 to 780	14	490	700 to 850	11
	63 < t ≤ 100	207	560 to 710	340	580 to 820	8	370	630 to 780	14	455	650 to 850	11

a For non-round products in the quenched and tempered conditions, see Figure B.1.  
 b For thickness <5 mm, the mechanical properties may be agreed at the time of enquiry and order.  
 c These values are also valid for the “cold drawn and quenched and tempered condition” (+C+QT).  
 d In case of dispute, the tensile strength values are the decisive factor.  
 e For flats and special sections, the proof strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) by ±10 %.

Table 8 — Mechanical properties of non-alloy bright steels for case hardening

Steel name	Thickness <sup>a</sup> <i>t</i> mm	Mechanical properties					
		As-rolled + peeled (+SH)		Cold drawn (+C)		+A + peeled (+A +SH)	+A + cold drawn (+A +C)
		Hardness <sup>c</sup> HBW	$R_m$ MPa	$R_{p0,2}$ <sup>b</sup> MPa min.	$R_m$ <sup>b</sup> MPa	A % min.	Hardness <sup>d</sup> HBW max.
C10E C10R	5 ≤ <i>t</i> ≤ 10	-	-	350	460 to 760	8	225
	10 < <i>t</i> ≤ 16	-	-	300	430 to 730	9	216
	16 < <i>t</i> ≤ 40	92 to 163	310 to 550	250	400 to 700	10	207
	40 < <i>t</i> ≤ 63	92 to 163	310 to 550	200	350 to 640	12	190
C15E C15R	63 < <i>t</i> ≤ 100	92 to 163	310 to 550	180	320 to 580	12	172
	5 ≤ <i>t</i> ≤ 10	-	-	380	500 to 800	7	238
	10 < <i>t</i> ≤ 16	-	-	340	480 to 780	8	231
	16 < <i>t</i> ≤ 40	98 to 178	330 to 600	280	430 to 730	9	216
C16E C16R	40 < <i>t</i> ≤ 63	98 to 178	330 to 600	240	380 to 670	11	198
	63 < <i>t</i> ≤ 100	98 to 178	330 to 600	215	340 to 600	12	178
	5 ≤ <i>t</i> ≤ 10	-	-	400	520 to 820	7	242
	10 < <i>t</i> ≤ 16	-	-	360	500 to 800	8	238
C16E C16R	16 < <i>t</i> ≤ 40	105 to 184	350 to 620	300	450 to 750	9	222
	40 < <i>t</i> ≤ 63	105 to 184	350 to 620	260	400 to 690	11	204
	63 < <i>t</i> ≤ 100	105 to 184	350 to 620	235	360 to 620	12	184

<sup>a</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>b</sup> For flats and special sections, the yield strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) by ±10 %.

<sup>c</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>d</sup> The hardness values for flats may deviate by ±10 %.

Table 9 — Mechanical properties of alloy bright steels for case hardening

Steel name	Thickness <sup>a</sup> <i>t</i> mm	Mechanical properties			
		+A+ peeled (+A+SH)  Hardness HBW max.	+A+cold drawn (+A+C)  Hardness <sup>b</sup> HBW max.	+FP+ peeled (+FP+SH)  Hardness HBW	+FP+cold drawn (+FP+C)  Hardness <sup>b</sup> HBW
20Cr4 20CrS4	5 ≤ <i>t</i> ≤ 10	-	-	-	-
	10 < <i>t</i> ≤ 16	-	-	-	-
	16 < <i>t</i> ≤ 40	197	-	-	140 to 240
	40 < <i>t</i> ≤ 63	197	-	-	140 to 240
	63 < <i>t</i> ≤ 100	197	-	-	140 to 240
16MnCr5 16MnCrS5	5 ≤ <i>t</i> ≤ 10	-	260	-	-
	10 < <i>t</i> ≤ 16	-	250	-	-
	16 < <i>t</i> ≤ 40	207	245	140 to 187	140 to 240
	40 < <i>t</i> ≤ 63	207	240	140 to 187	140 to 235
	63 < <i>t</i> ≤ 100	207	240	140 to 187	140 to 235
20MnCr5 20MnCrS5	5 ≤ <i>t</i> ≤ 10	-	270	-	-
	10 < <i>t</i> ≤ 16	-	260	-	-
	16 < <i>t</i> ≤ 40	217	255	152 to 201	152 to 250
	40 < <i>t</i> ≤ 63	217	250	152 to 201	152 to 245
	63 < <i>t</i> ≤ 100	217	250	152 to 201	152 to 245
24CrMo4 24CrMoS4	5 ≤ <i>t</i> ≤ 10	-	270	-	-
	10 < <i>t</i> ≤ 16	-	260	-	-
	16 < <i>t</i> ≤ 40	212	255	-	-
	40 < <i>t</i> ≤ 63	212	250	-	-
	63 < <i>t</i> ≤ 100	212	250	-	-
16NiCr4 16NiCrS4	5 ≤ <i>t</i> ≤ 10	-	270	-	-
	10 < <i>t</i> ≤ 16	-	260	-	-
	16 < <i>t</i> ≤ 40	217	255	156 to 207	156 to 245
	40 < <i>t</i> ≤ 63	217	255	156 to 207	156 to 240
	63 < <i>t</i> ≤ 100	217	255	156 to 207	156 to 240
20NiCrMo2-2 20NiCrMoS2-2	5 ≤ <i>t</i> ≤ 10	-	270	-	-
	10 < <i>t</i> ≤ 16	-	260	-	-
	16 < <i>t</i> ≤ 40	212	255	149 to 194	149 to 240
	40 < <i>t</i> ≤ 63	212	255	149 to 194	149 to 235
	63 < <i>t</i> ≤ 100	212	255	149 to 194	149 to 235
17NiCrMo6-4 17NiCrMoS6-4	5 ≤ <i>t</i> ≤ 10	-	275	-	-
	10 < <i>t</i> ≤ 16	-	265	-	-
	16 < <i>t</i> ≤ 40	229	260	149 to 201	149 to 250
	40 < <i>t</i> ≤ 63	229	255	149 to 201	149 to 245
	63 < <i>t</i> ≤ 100	229	255	149 to 201	149 to 245

<sup>a</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>b</sup> The hardness values for flats may deviate by ±10 %.

Table 9 (continued)

Steel name	Thickness <sup>a</sup> <i>t</i> mm	Mechanical properties			
		+A+ peeled (+A+SH)  Hardness HBW max.	+A+cold drawn (+A+C)  Hardness <sup>b</sup> HBW max.	+FP+ peeled (+FP+SH)  Hardness HBW	+FP+cold drawn (+FP+C)  Hardness <sup>b</sup> HBW
18CrNiMo7-6	$5 \leq t \leq 10$	-	-	-	-
	$10 < t \leq 16$	-	-	-	-
	$16 < t \leq 40$	229	-	149 to 201	149 to 280
	$40 < t \leq 63$	229	-	149 to 201	149 to 280
	$63 < t \leq 100$	229	-	149 to 201	149 to 280
<sup>a</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order. <sup>b</sup> The hardness values for flats may deviate by $\pm 10$ %.					

Table 10 — Mechanical properties of non-alloy bright steels for quenching and tempering

Steel name	Thickness- s <sup>a, b</sup> t mm	Mechanical properties											
		As-rolled + peeled (+SH)		Cold drawn (+C)			Quenched and tempered and peeled or cold drawn and quenched and tempered (+QT+SH or +C+QT)				Quenched and tempered + cold drawn (+QT +C)		
		Hardness <sup>c</sup> HBW	R <sub>m</sub> MPa	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	KV <sub>2</sub> J min.	R <sub>p0,2</sub> <sup>d</sup> MPa min.	R <sub>m</sub> <sup>d</sup> MPa	A % min.
C25E C25R	5 ≤ t ≤ 10	-	-	420	560 to 860	6	-	-	-	-	-	-	-
	10 < t ≤ 16	-	-	380	530 to 880	7	-	-	-	-	-	-	-
	16 < t ≤ 40	130 to 187	440 to 640	300	510 to 810	8	320	500 to 650	20	45	-	-	-
	40 < t ≤ 63	130 to 187	440 to 640	265	490 to 790	9	-	-	-	-	-	-	-
C30E C30R	63 < t ≤ 100	130 to 187	440 to 640	245	440 to 740	10	-	-	-	-	-	-	-
	5 ≤ t ≤ 10	-	-	455	610 to 910	6	-	-	-	-	-	-	-
	10 < t ≤ 16	-	-	420	570 to 870	7	-	-	-	-	-	-	-
	16 < t ≤ 40	145 to 198	480 to 680	345	550 to 850	8	350	550 to 750	20	40	-	-	-
C35E C35R	40 < t ≤ 63	145 to 198	480 to 680	300	520 to 820	9	300	500 to 650	20	40	-	-	-
	63 < t ≤ 100	145 to 198	480 to 680	250	480 to 780	9	300	500 to 650	20	40	-	-	-
	5 ≤ t ≤ 10	-	-	510	650 to 1 000	6	-	-	-	-	525	750 to 950	9
	10 < t ≤ 16	-	-	420	600 to 950	7	-	-	-	-	490	700 to 900	9
C35E C35R	16 < t ≤ 40	156 to 204	520 to 700	320	580 to 880	8	370	600 to 750	19	35	455	650 to 850	10
	40 < t ≤ 63	156 to 204	520 to 700	300	550 to 840	9	320	550 to 700	20	35	400	570 to 770	11
	63 < t ≤ 100	156 to 204	520 to 700	270	520 to 800	9	320	550 to 700	20	35	385	550 to 750	12

<sup>a</sup> For non-round products in the quenched and tempered conditions, see [Figure B.1](#).

<sup>b</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>d</sup> For flats and special sections, the proof strength (R<sub>p0,2</sub>) may deviate by -10 % and the tensile strength (R<sub>m</sub>) may deviate by ±10 %.

Table 10 (continued)

Steel name	Thickness- s <sup>a, b</sup> t mm	Mechanical properties												
		As-rolled + peeled (+SH)		Cold drawn (+C)		Quenched and tempered and peeled or cold drawn and quenched and tempered (+QT+SH or +C+QT)				Quenched and tempered + cold drawn (+QT+C)				
		Hardness <sup>c</sup> HBW	R <sub>m</sub> MPa	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	R <sub>p0,2</sub> MPa min.	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	KV <sub>2</sub> J min.	R <sub>p0,2</sub> <sup>d</sup> MPa min.	R <sub>m</sub> <sup>d</sup> MPa	A % min.
C40E C40R	5 ≤ t ≤ 10	-	-	540 to 1 000	700 to 1 000	6	-	-	-	-	-	560	800 to 1 000	8
	10 < t ≤ 16	-	-	460	650 to 980	7	-	-	-	-	-	525	750 to 950	8
	16 < t ≤ 40	164 to 207	550 to 710	365	620 to 920	8	400	630 to 780	18	30	490	490	680 to 880	9
	40 < t ≤ 63	164 to 207	550 to 710	330	590 to 840	9	350	600 to 750	19	30	435	435	620 to 820	10
C45E C45R	63 < t ≤ 100	164 to 207	550 to 710	290	550 to 820	9	350	600 to 750	19	30	420	420	600 to 800	11
	5 ≤ t ≤ 10	-	-	565	750 to 1 050	5	-	-	-	-	-	595	850 to 1 050	8
	10 < t ≤ 16	-	-	500	710 to 1 030	6	-	-	-	-	-	565	810 to 1 010	8
	16 < t ≤ 40	172 to 241	580 to 820	410	650 to 1 000	7	430	650 to 800	16	25	525	525	700 to 900	9
	40 < t ≤ 63	172 to 241	580 to 820	360	630 to 900	8	370	630 to 780	17	25	455	455	650 to 850	10
	63 < t ≤ 100	172 to 241	580 to 820	310	580 to 850	8	370	630 to 780	17	25	455	455	650 to 850	11

<sup>a</sup> For non-round products in the quenched and tempered conditions, see [Figure B.1](#).

<sup>b</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>d</sup> For flats and special sections, the proof strength (R<sub>p0,2</sub>) may deviate by -10 % and the tensile strength (R<sub>m</sub>) may deviate by ±10 %.

Table 10 (continued)

Steel name	Thickness- s <sup>a,b</sup> t mm	Mechanical properties												
		As-rolled + peeled (+SH)			Cold drawn (+C)			Quenched and tempered and or cold drawn and quenched and tempered (+QT+SH or +C+QT)				Quenched and tempered + cold drawn (+QT +C)		
		Hardness <sup>c</sup> HBW	R <sub>m</sub> MPa	R <sub>p0,2</sub> MPa min.	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	KV <sub>2</sub> J min.	R <sub>p0,2</sub> <sup>d</sup> MPa min.	R <sub>m</sub> <sup>d</sup> MPa	A % min.
C50E C50R	5 ≤ t ≤ 10	-	-	590	770 to 1 100	5	-	-	-	-	610	870 to 1 070	7	
	10 < t ≤ 16	-	-	520	730 to 1 080	6	-	-	-	-	580	830 to 1 030	7	
	16 < t ≤ 40	179 to 269	610 to 910	440	690 to 1 050	7	460	700 to 850	15	-	555	790 to 990	8	
	40 < t ≤ 63	179 to 269	610 to 910	390	650 to 1 030	8	400	650 to 800	16	-	510	730 to 930	9	
	63 < t ≤ 100	179 to 269	610 to 910	-	-	-	400	650 to 800	16	-	475	680 to 880	9	
C60E C60R	5 ≤ t ≤ 10	-	-	630	800 to 1 150	5	-	-	-	-	630	900 to 1 100	6	
	10 < t ≤ 16	-	-	550	780 to 1 130	5	-	-	-	-	615	880 to 1 080	6	
	16 < t ≤ 40	196 to 278	670 to 940	480	730 to 1 100	6	520	800 to 950	13	-	580	830 to 1 030	7	
	40 < t ≤ 63	196 to 278	670 to 940	-	-	-	450	750 to 900	14	-	545	780 to 980	8	
	63 < t ≤ 100	196 to 278	670 to 940	-	-	-	450	750 to 900	14	-	525	750 to 950	8	
28Mn6	16 < t ≤ 40	-	-	-	-	-	490	700 to 850	15	40	-	-	-	
	40 < t ≤ 63	-	-	-	-	-	440	650 to 800	16	40	-	-	-	
	63 < t ≤ 100	-	-	-	-	-	440	650 to 800	16	40	-	-	-	

<sup>a</sup> For non-round products in the quenched and tempered conditions, see Figure B.1.

<sup>b</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>d</sup> For flats and special sections, the proof strength (R<sub>p0,2</sub>) may deviate by -10 % and the tensile strength (R<sub>m</sub>) may deviate by ±10.

Table 10 (continued)

Steel name	Thickness- s <sup>a,b</sup> t mm	Mechanical properties											
		As-rolled + peeled (+SH)		Cold drawn (+C)		Quenched and tempered and peeled or cold drawn and quenched and tempered (+QT+SH or +C+QT)				Quenched and tempered + cold drawn (+QT +C)			
		Hardness <sup>c</sup> HBW	R <sub>m</sub> MPa	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	R <sub>p0,2</sub> MPa min.	R <sub>m</sub> MPa	A % min.	KV <sub>2</sub> J min.	R <sub>p0,2</sub> <sup>d</sup> MPa min.	R <sub>m</sub> <sup>d</sup> MPa	A % min.
36Mn6	16 < t ≤ 40	-	-	-	-	-	540	750 to 900	14	40	-	-	-
	40 < t ≤ 63	-	-	-	-	-	460	700 to 850	15	40	-	-	-
	63 < t ≤ 100	-	-	-	-	-	460	700 to 850	15	40	-	-	-
42Mn6	16 < t ≤ 40	-	-	-	-	-	590	800 to 900	14	40	-	-	-
	40 < t ≤ 63	-	-	-	-	-	480	750 to 900	15	40	-	-	-
	63 < t ≤ 100	-	-	-	-	-	480	750 to 900	15	40	-	-	-

<sup>a</sup> For non-round products in the quenched and tempered conditions, see Figure B.1.

<sup>b</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and/or order.

<sup>c</sup> In case of dispute, the tensile strength values are the decisive factor.

<sup>d</sup> For flats and special sections, the proof strength (R<sub>p0,2</sub>) may deviate by -10 % and the tensile strength (R<sub>m</sub>) may deviate by ±10.

Table 11 — Mechanical properties of bright alloy steels for quenching and tempering

Steel name	Thickness- $s_{a,b}$ $t$ mm	Mechanical properties									
		Soft annealed + peeled (+A,+SH) Hardness HBW max.		Soft annealed + Cold drawn (+A +C) Hardness HBW max.		Quenched and tempered and peeled or cold drawn and quenched and tempered (+QT+SH or +C+QT)			Quenched and tempered + cold drawn (+QT +C)		
				$R_{p0,2}$ MPa min.	$R_m$ MPa	A % min.	KV <sub>2</sub> J min.	$R_{p0,2}^c$ MPa min.	$R_m^c$ MPa	A % min.	
34Cr4 34CrS4	5 ≤ t ≤ 10	-	285	-	-	-	-	700	900 to 1 100	8	
	10 < t ≤ 16	-	275	-	-	-	-	700	900 to 1 100	9	
	16 < t ≤ 40	223	270	590	800 to 950	14	40	580	800 to 1 000	9	
	40 < t ≤ 63	223	265	460	700 to 850	15	40	510	700 to 900	10	
	63 < t ≤ 100	223	265	460	700 to 850	15	40	480	700 to 900	11	
37Cr4 37CrS4	5 ≤ t ≤ 10	-	-	-	-	-	-	-	-	-	
	10 < t ≤ 16	-	-	-	-	-	-	-	-	-	
	16 < t ≤ 40	235	-	630	850 to 1 000	13	35	-	-	-	
	40 < t ≤ 63	235	-	510	750 to 900	14	35	-	-	-	
	63 < t ≤ 100	235	-	510	750 to 900	14	35	-	-	-	
41Cr4 41CrS4	5 ≤ t ≤ 10	-	295	-	-	-	-	770	1 000 to 1 200	8	
	10 < t ≤ 16	-	285	-	-	-	-	750	1 000 to 1 200	8	
	16 < t ≤ 40	241	280	660	900 to 1 100	12	35	670	900 to 1 100	9	
	40 < t ≤ 63	241	270	560	800 to 950	14	35	570	800 to 1 000	10	
	63 < t ≤ 100	241	270	560	800 to 950	14	35	570	800 to 1 000	11	
25CrMo4 25CrMoS4	5 ≤ t ≤ 10	-	270	-	-	-	-	700	900 to 1 100	9	
	10 < t ≤ 16	-	260	-	-	-	-	700	900 to 1 100	9	
	16 < t ≤ 40	212	255	600	800 to 950	14	50	600	800 to 1 000	10	
	40 < t ≤ 63	212	250	450	700 to 850	15	50	520	700 to 900	11	
	63 < t ≤ 100	212	250	450	700 to 850	15	50	450	700 to 900	12	

<sup>a</sup> For non-round products in the quenched and tempered conditions, see Figure B.1.

<sup>b</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> For flats and special sections, the proof strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) may deviate by ±10.

Table 11 (continued)

Steel name	Thickness- $s_{a,b}$ $t$ mm	Mechanical properties										
		Soft annealed + peeled (+A +SH)		Soft annealed + Cold drawn (+A +C)		Quenched and tempered and peeled or cold drawn and quenched and tempered (+QT+SH or +C+QT)			Quenched and tempered + cold drawn (+QT +C)			
		Hardness HBW max.	Hardness HBW max.	$R_{p0,2}$ MPa min.	$R_m$ MPa	A % min.	KV <sub>2</sub> J min.	$R_{p0,2}^c$ MPa min.	$R_m^c$ MPa	$R_c^c$ MPa	A % min.	
34CrMo4 34CrMoS4	5 ≤ t ≤ 10	-	-	-	-	-	-	-	-	-	-	-
	10 < t ≤ 16	-	-	-	-	-	-	-	-	-	-	-
	16 < t ≤ 40	223	-	650	900 to 1 100	12	40	-	-	-	-	-
	40 < t ≤ 63	223	-	550	800 to 950	14	45	-	-	-	-	-
	63 < t ≤ 100	223	-	550	800 to 950	14	45	-	-	-	-	-
42CrMo4 42CrMoS4	5 ≤ t ≤ 10	-	300	-	-	-	-	770	1 000 to 1 200	-	8	-
	10 < t ≤ 16	-	290	-	-	-	-	750	1 000 to 1 200	-	8	-
	16 < t ≤ 40	241	285	750	1 000 to 1 200	11	35	720	1 000 to 1 200	-	9	-
	40 < t ≤ 63	241	280	650	900 to 1 100	12	35	650	900 to 1 100	-	10	-
	63 < t ≤ 100	241	280	650	900 to 1 100	12	35	650	900 to 1 100	-	10	-
50CrMo4	5 ≤ t ≤ 10	-	-	-	-	-	-	-	-	-	-	-
	10 < t ≤ 16	-	-	-	-	-	-	-	-	-	-	-
	16 < t ≤ 40	248	-	780	1 000 to 1 200	10	30	-	-	-	-	-
	40 < t ≤ 63	248	-	700	900 to 1 100	12	30	-	-	-	-	-
	63 < t ≤ 100	248	-	700	900 to 1 100	12	30	-	-	-	-	-

<sup>a</sup> For non-round products in the quenched and tempered conditions, see Figure B.1.

<sup>b</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> For flats and special sections, the proof strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) may deviate by ±10.

Table 11 (continued)

Steel name	Thickness- $s_{a,b}$ $t$ mm	Mechanical properties									
		Soft annealed + peeled (+A +SH)		Soft annealed + Cold drawn (+A +C)		Quenched and tempered and peeled or cold drawn and quenched and tempered (+QT+SH or +C+QT)				Quenched and tempered + cold drawn (+QT +C)	
		Hardness HBW max.	Hardness HBW max.	$R_{p0,2}$ MPa min.	$R_m$ MPa	A % min.	KV <sub>2</sub> J min.	$R_{p0,2}^c$ MPa min.	$R_m^c$ MPa	$R_m^c$ MPa	A % min.
51CrV4	$t \leq 16$	248	311	900	1 100 to 1 300	9	-	-	-	-	-
	$16 < t \leq 40$	248	293	800	1 000 to 1 200	10	30	-	-	-	-
	$40 < t \leq 80$	248	287	700	900 to 1 100	12	30	-	-	-	-
	$5 \leq t \leq 10$ $10 < t \leq 16$	-	-	-	-	-	-	-	-	-	-
36CrNiMo4	$16 < t \leq 40$	248	-	800	1 000 to 1 200	11	40	-	-	-	-
	$40 < t \leq 63$	248	-	700	900 to 1 100	12	45	-	-	-	-
	$63 < t \leq 100$	248	-	700	900 to 1 100	12	45	-	-	-	-
34CrNiMo6	$5 \leq t \leq 10$	-	308	-	-	-	-	770	1 000 to 1 200	-	8
	$10 < t \leq 16$	-	298	-	-	-	-	750	1 000 to 1 200	-	8
	$16 < t \leq 40$	248	293	900	1 100 to 1 300	10	40	720	1 000 to 1 200	-	9
	$40 < t \leq 63$	248	288	800	1 000 to 1 200	11	45	650	1 000 to 1 200	-	10
	$63 < t \leq 100$	248	288	800	1 000 to 1 200	11	45	650	1 000 to 1 200	-	10

a For non-round products in the quenched and tempered conditions, see Figure B.1.  
 b For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.  
 c For flats and special sections, the proof strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) may deviate by ±10.

Table 11 (continued)

Steel name	Thickness- $s^{a,b}$ $t$ mm	Mechanical properties									
		Soft annealed + peeled (+A +SH) Hardness HBW max.	Soft annealed + Cold drawn (+A +C) Hardness HBW max.	Quenched and tempered and peeled or cold drawn and quenched and tempered (+QT+SH or +C+QT)			Quenched and tempered + cold drawn (+QT+C)				
				$R_{p0,2}$ MPa min.	$R_m$ MPa	A % min.	KV <sub>2</sub> J min.	$R_{p0,2}^c$ MPa min.	$R_m^c$ MPa	A % min.	
30CrNiMo8	$5 \leq t \leq 10$	-	-	-	-	-	-	-	-	-	
	$10 < t \leq 16$	-	-	-	-	-	-	-	-	-	
	$16 < t \leq 40$	248	-	850	1 030 to 1 230	12	30	-	-	-	
	$40 < t \leq 63$	248	-	800	980 to 1 180	12	35	-	-	-	
	$63 < t \leq 100$	248	-	800	980 to 1 180	12	35	-	-	-	

<sup>a</sup> For non-round products in the quenched and tempered conditions, see Figure B.1.

<sup>b</sup> For thicknesses <5 mm, the mechanical properties may be agreed at the time of enquiry and order.

<sup>c</sup> For flats and special sections, the proof strength ( $R_{p0,2}$ ) may deviate by -10 % and the tensile strength ( $R_m$ ) may deviate by  $\pm 10$ .

**Table 12 — Tolerance classes for rounds, squares and hexagons**

Nominal thickness mm	Tolerance class to ISO 286-2 <sup>a</sup>						
	mm						
	h6	h7	h8	h9	h10	h11	h12
$1 < t \leq 3$	0,006	0,010	0,014	0,025	0,040	0,060	0,100
$3 < t \leq 6$	0,008	0,012	0,018	0,030	0,048	0,075	0,120
$6 < t \leq 10$	0,009	0,015	0,022	0,036	0,058	0,090	0,150
$10 < t \leq 18$	0,011	0,018	0,027	0,043	0,070	0,110	0,180
$18 < t \leq 30$	0,013	0,021	0,033	0,052	0,084	0,130	0,210
$30 < t \leq 50$	0,016	0,025	0,039	0,062	0,100	0,160	0,250
$50 < t \leq 80$	0,019	0,030	0,046	0,074	0,120	0,190	0,300
$80 < t \leq 120$	0,022	0,035	0,054	0,087	0,140	0,220	0,350
$120 < t \leq 180$	0,025	0,040	0,063	0,100	0,160	0,250	0,400
$180 < t \leq 250$	0,029	0,046	0,072	0,115	0,185	0,290	0,460

<sup>a</sup> The above deviation values are negatively disposed about the nominal dimension. For example, a 20 mm nominal diameter having a tolerance class h9 has 20 mm +0/-0,052 mm or 19,948/20,000 mm.

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Table 13 — Tolerances for drawn flats

Width mm	Deviation		ISO 286-2 Class
	mm	mm	
$w \leq 18$	-	-	h11
$18 < w \leq 30$	+ 0	-0,13	h11
$30 < w \leq 50$	+ 0	-0,16	h11
$50 < w \leq 80$	+ 0	-0,19	h11
$80 < w \leq 100$	+ 0	-0,22	h11
$100 < w \leq 150$	+ 0,50	-0,50	-
$150 < w \leq 200$	+ 1,00	-1,00	-
$200 < w \leq 300$	+ 2,00	-2,00	-
$300 < w \leq 400$	+ 2,50	-2,50	-
$400 < w \leq 500$	+ 1 %	- 1 %	-
Thickness <sup>b</sup> mm	Deviation <sup>a</sup>		
	mm	mm	
$3 < t \leq 6$	+ 0	-0,075	h11
$6 < t \leq 10$	+ 0	-0,090	h11
$10 < t \leq 18$	+ 0	-0,11	h11
$18 < t \leq 30$	+ 0	-0,13	h11
$30 < t \leq 50$	+ 0	-0,16	h11
$50 < t \leq 60$	+ 0	-0,19	h11
$60 < t \leq 80$	+ 0	-0,30	h12
$80 < t \leq 120$	+ 0	-0,35	h12
$120 < t \leq 140$	+ 0	-0,40	h12
<sup>a</sup> The tolerances in this table apply to low carbon ( $C \leq 0,20$ %) and low carbon free-cutting steels only. For all other steels, deviation may increase to 150 % of the mentioned deviation in this table.			
<sup>b</sup> For $w > 150$ mm and $t \leq 18$ mm the tolerance of the thickness is h12.			

**Table 14 — Types of length and length tolerances**

Type of length	Length mm	Length tolerance mm	To be stated on order
manufacturing length <sup>a</sup>	3 000 to 9 000	±500	length
stock length <sup>a</sup>	3 000 or 6 000	0, +200 0, +400	e.g. stock 6 000
cut to length	up to 9 000	corresponding to agreement, but at least ±5 minimum	length and tolerance

<sup>a</sup> Short bars: each bundle may contain a percentage of short bars.  
 — Dimensions ≤25 mm: the percentage is 5 % maximum, the length of these short bars being at the minimum two thirds the nominal length ordered.  
 — Dimensions >25 mm: the percentage is 10 % maximum, with the same restriction on the minimum length.  
 If agreed at the time of enquiry and order bright products are delivered without any short bars.

**Table 15 — Deviation from straightness for rounds, squares and hexagons <sup>a</sup>**

Product form	Steel group	Nominal dimension mm	Deviation max. mm
Rounds	Non-alloy steels <0,25 % C		1,0
	Non-alloy steels ≥0,25 % C, alloy steels, quenched and tempered steels		1,5
Squares and hexagons	Non-alloy steels <0,25 % C	$t \leq 75$	1,0
	Non-alloy steels ≥0,25 % C, alloy steels, quenched and tempered steels	$t \leq 75$	2,0
	Non-alloy steels < 0,25 % C	$t > 75$	1,5
	Non-alloy steels ≥0,25 % C, alloy steels, quenched and tempered steels	$t > 75$	2,5

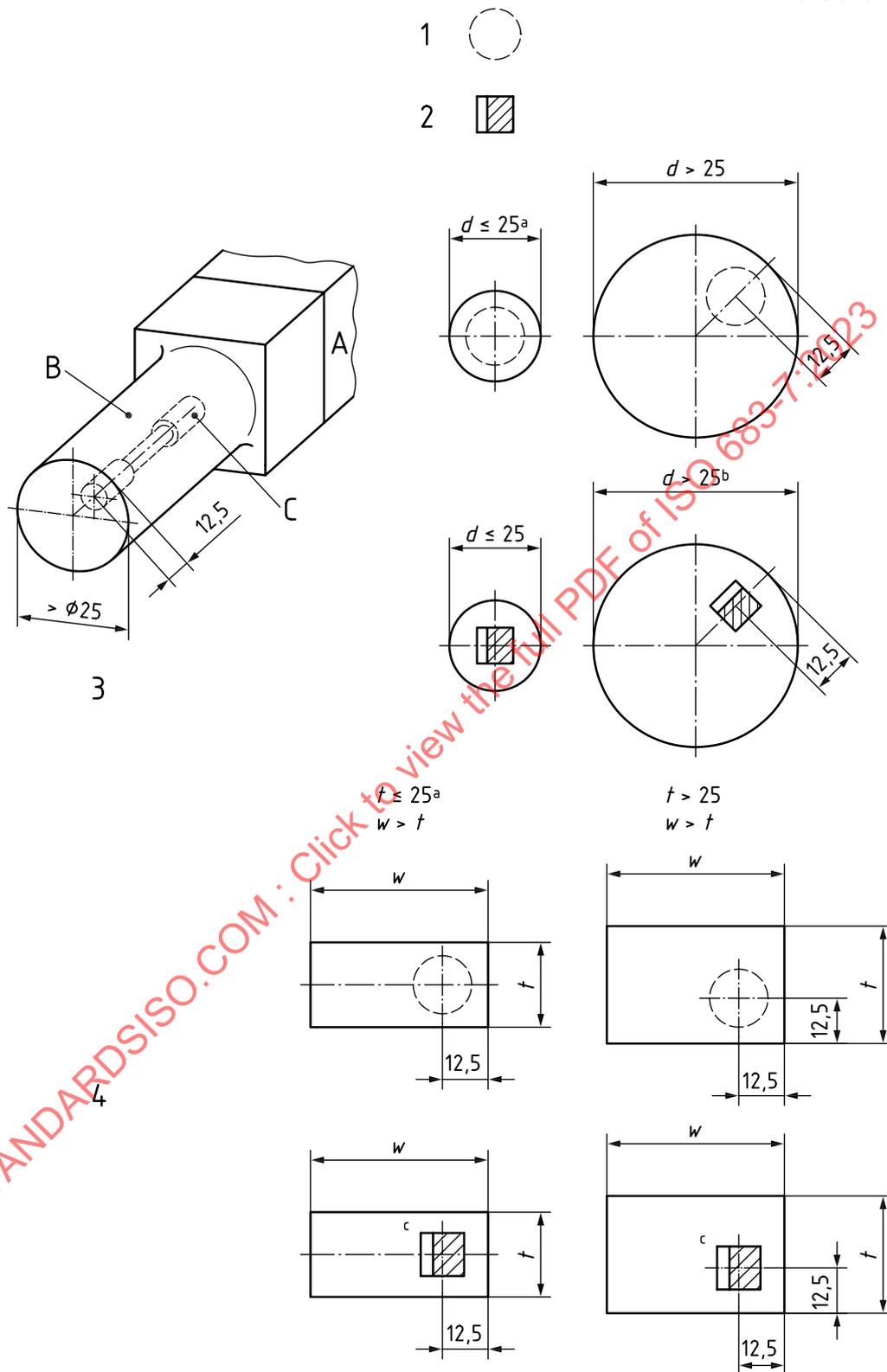
<sup>a</sup> For the method of evaluating straightness see [Annex D](#).

**Table 16 — Deviation from straightness for flats <sup>a</sup>**

Product form	Steel group	Nominal dimension mm	Deviation on width and thickness max. mm	
			for $w/t \geq 10:1$	for $w/t < 10:1$
Flats	Non-alloy steels < 0,25 % C	$w < 120$	2	1,5
		$w \geq 120$	2,5	2
	Non-alloy steels ≥ 0,25 % C, alloy steels, quenched and tempered steels	$w < 120$	2,5	2
		$w \geq 120$	3	2,5

<sup>a</sup> For the method of evaluating straightness, see [Annex D](#).

Dimensions in millimetres



**Key**

- 1 tensile test piece
- 2 notched bar impact test piece
- 3 round and similar shaped sections
- 4 rectangular and square sections
- A sample

- B rough specimen
- C test piece
- a For small products ( $d$  or  $w \leq 25$  mm), the test piece should, if possible, consist of an unmachined part of the bar.
- b For round bars, the longitudinal axis of the notch shall be about parallel to the direction of a diameter.
- c For rectangular bars, the longitudinal axis of the notch shall be perpendicular to the wider rolling surface.

**Figure 1 — Location of the test pieces in bars**

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**Annex A**  
(informative)

**Steel grades and chemical composition according to ISO 630-2,  
ISO 683-1, ISO 683-2, ISO 683-3 and ISO 683-4**

The chemical composition given in this annex is according to ISO 630-2, ISO 683-1, ISO 683-2, ISO 683-3 and ISO 683-4.

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**Table A.1 — Steel grades and chemical composition (cast analysis) of general engineering bright steels** (chemical composition as listed in ISO 630-2 and ISO 683-1)

Steel name	Steel grades according to ISO 630-2 %, mass fraction <sup>a</sup>									
	C in % max. for nominal product thickness mm			Si	Mn	P	S <sup>c, d</sup>	N <sup>e</sup>	Cu <sup>f</sup>	Others
	$t \leq 16$	$16 < t \leq 40$	$40 < t \leq 100$							
S235B	0,17	0,17	0,20	–	1,40	0,035	0,035	0,012	0,55	–
S355D	0,20	0,20	0,22	0,55	1,60	0,025	0,025	–	0,55	–
Steel name	Steel grades according to ISO 683-1 %, mass fraction <sup>a, b</sup>									
	C	Si <sup>g</sup>	Mn	P	S	Cr	Mo	Ni	Cu	Cr+ Mo+Ni
C25	0,22 to 0,29	0,10 to 0,40	0,40 to 0,70	0,045	0,045	0,40	0,10	0,40	0,30	0,63
C30	0,27 to 0,34	0,10 to 0,40	0,50 to 0,80	0,045	0,045	0,40	0,10	0,40	0,30	0,63
C35	0,32 to 0,39	0,10 to 0,40	0,50 to 0,80	0,045	0,045	0,40	0,10	0,40	0,30	0,63
C40	0,37 to 0,44	0,10 to 0,40	0,50 to 0,80	0,045	0,045	0,40	0,10	0,40	0,30	0,63
C45	0,42 to 0,50	0,10 to 0,40	0,50 to 0,80	0,045	0,045	0,40	0,10	0,40	0,30	0,63
C50	0,47 to 0,55	0,10 to 0,40	0,60 to 0,90	0,045	0,045	0,40	0,10	0,40	0,30	0,63
C60	0,57 to 0,65	0,10 to 0,40	0,60 to 0,90	0,045	0,045	0,40	0,10	0,40	0,30	0,63

Elements not quoted 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 should be taken to prevent the addition, from scrap or other material used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.

<sup>a</sup> Maximum values unless indicated otherwise.

<sup>b</sup> Steels with improved machinability either by higher sulfur levels up to about 0,10 % S (including controlled sulphide morphology) or lead additions may be available on request. In the first case, the upper limit of the Mn-content may be increased by 0,15 %.

<sup>c</sup> The max. S content may be increased for improved machinability by 0,015 % by agreement if the steel is treated to modify the sulphide morphology and if the chemical composition shows min 0,002 0 % Ca.

<sup>d</sup> The P and S content may be 0,005 % higher.

<sup>e</sup> The maximum value for nitrogen does not apply if the chemical composition shows a minimum total Al content of 0,020 % or, alternatively, minimum 0,015 % acid soluble Al or if sufficient other N-binding elements are present. In this case, the N-binding elements shall be mentioned in the inspection document.

<sup>f</sup> Cu content above 0,40 % can cause hot shortness during hot forming.

<sup>g</sup> Steels may be supplied with a lower silicon content. In this case, alternative means of deoxidation shall be used.

**Table A.2 — Steel grades and chemical composition (cast analysis) of free-cutting bright steels**  
(chemical composition as listed in ISO 683-4)

Steel name	% mass fraction <sup>a</sup>					
	C	Si	Mn	P	S	Pb
Steels not intended for heat treatment						
9S20	0,13	0,05 <sup>b</sup>	0,60 to 1,20	0,11 <sup>c</sup>	0,15 to 0,25	–
11SMn30	0,14	0,05 <sup>b</sup>	0,90 to 1,30	0,11 <sup>c</sup>	0,27 to 0,33	–
11SMnPb30						0,20 to 0,35
11SMn37	0,14	0,05 <sup>b</sup>	1,00 to 1,50	0,11 <sup>c</sup>	0,34 to 0,40	–
11SMnPb37						0,20 to 0,35
Case-hardening steels						
10S20	0,07 to 0,13	0,40	0,70 to 1,10	0,060	0,15 to 0,25	–
10SPb20						0,20 to 0,35
15SMn13	0,12 to 0,18	0,40	0,90 to 1,30	0,060	0,08 to 0,18	–
17SMn20	0,14 to 0,20	0,40	1,20 to 1,60	0,060	0,15 to 0,25	–
Steels for quenching and tempering						
35S20	0,32 to 0,39	0,40	0,70 to 1,10	0,060	0,15 to 0,25	–
35SPb20						0,15 to 0,35
36SMn14	0,32 to 0,39	0,40	1,30 to 1,70	0,060	0,10 to 0,18	–
36SMnPb14						0,15 to 0,35
35SMn20	0,32 to 0,39	0,40	0,90 to 1,40	0,060	0,15 to 0,25	–
35SMnPb20						0,15 to 0,35
38SMn28	0,35 to 0,40	0,40	1,20 to 1,50	0,060	0,24 to 0,33	–
38SMnPb28						0,15 to 0,35
44SMn28	0,40 to 0,48	0,40	1,30 to 1,70	0,060	0,24 to 0,33	–
44SMnPb28						0,15 to 0,35
46S20	0,42 to 0,50	0,40	0,70 to 1,10	0,060	0,15 to 0,25	–
46SPb20						0,15 to 0,35
<p>Elements not quoted in this 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 mechanical properties and applicability. However, if agreed, the manufacturer may add elements such as Ca, Se, Te, etc. for the purpose of improving the machinability. These elements shall be reported in the inspection document.</p> <p><sup>a</sup> Maximum values unless otherwise indicated.</p> <p><sup>b</sup> Since silicon has an adverse effect on machinability, it is not intentionally added to specified limits, but if the formation of special oxides is guaranteed, a Si-content of 0,10 % to 0,40 % may be agreed.</p> <p><sup>c</sup> At the time of enquiry and order, it may be agreed that either a grade with 0,06 % to 0,11 % P or a grade with max. 0,05 % P shall be delivered.</p>						

**Table A.3 — Steel grades and chemical composition (cast analysis) of bright steels for case hardening (chemical composition as listed in ISO 683-3)**

Steel name	% mass fraction <sup>a, b</sup>									
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Others
Non-alloy steels for case hardening										
C10E	0,07 to 0,13	0,40	0,30 to 0,60	0,025	0,035	0,40	0,10	0,40	0,30	-
C10R					0,020 to 0,040					
C15E	0,12 to 0,18	0,40	0,30 to 0,60	0,025	0,035	0,40	0,10	0,40	0,30	-
C15R					0,020 to 0,040					
C16E	0,12 to 0,18	0,40	0,60 to 0,90	0,025	0,035	0,40	0,10	0,40	0,30	-
C16R					0,020 to 0,040					
Alloy steels for case hardening										
20Cr4	0,17 to 0,23	0,40	0,60 to 0,90	0,025	0,035	0,90 to 1,20	-	-	0,40	-
20CrS4					0,020 to 0,040					
16MnCr5	0,14 to 0,19	0,40	1,00 to 1,30	0,025	0,035	0,80 to 1,10	-	-	0,40	-
16MnCrS5					0,020 to 0,040					
20MnCr5	0,17 to 0,22	0,40	1,10 to 1,40	0,025	0,035	1,00 to 1,30	-	-	0,40	-
20MnCrS5					0,020 to 0,040					
24CrMo4 <sup>c</sup>	0,20 to 0,27	0,40	0,60 to 0,90	0,025	0,035	0,90 to 1,20	0,15 to 0,30	-	0,40	-
24CrMoS4 <sup>c</sup>					0,020 to 0,040					
16NiCr4	0,13 to 0,19	0,40	0,70 to 1,00	0,025	0,035	0,60 to 1,00	-	0,80 to 1,10	0,40	-
16NiCrS4					0,020 to 0,040					
20NiCr- Mo2-2	0,17 to 0,23	0,40	0,65 to 0,95	0,025	0,035	0,35 to 0,70	0,15 to 0,25	0,40 to 0,70	0,40	-
20NiCr- MoS2-2					0,020 to 0,040					
17NiCr- Mo6-4	0,14 to 0,20	0,15 to 0,40	0,60 to 0,90	0,025	0,035	0,80 to 1,10	0,15 to 0,25	1,20 to 1,60	0,40	-
17NiCr- MoS6-4					0,020 to 0,040					
18CrNi- Mo7-6	0,15 to 0,21	0,40	0,50 to 0,90	0,025	0,035	1,50 to 1,80	0,25 to 0,35	1,40 to 1,70	0,40	-

Elements not quoted 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 should be taken to prevent the addition, from scrap or other material used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.

<sup>a</sup> Maximum values unless indicated otherwise.

<sup>b</sup> Steels with improved machinability either by higher sulfur levels up to about 0,10 % S (including controlled sulphide morphology) or lead additions may be available on request. In the first case, the upper limit of the Mn-content may be increased by 0,15 %.

<sup>c</sup> This grade differs from 25CrMo4 for quenching and tempering concerning the chemical composition and the requirement on fine grain structure.

**Table A.4 — Steel grades and chemical composition (cast analysis) of bright steels for quenching and tempering** (chemical composition as listed in ISO 683-1 and ISO 683-2)

Steel name	% , mass fraction <sup>a, b</sup>									
	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Others
Non-alloy steels for quenching and tempering										
C25E	0,22 to 0,29	0,10 to 0,40	0,40 to 0,70	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
C25R					0,020 to 0,040					
C30E	0,27 to 0,34	0,10 to 0,40	0,50 to 0,80	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
C30R					0,020 to 0,040					
C35E	0,32 to 0,39	0,10 to 0,40	0,50 to 0,80	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
C35R					0,020 to 0,040					
C40E	0,37 to 0,44	0,10 to 0,40	0,50 to 0,80	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
C40R					0,020 to 0,040					
C45E	0,42 to 0,50	0,10 to 0,40	0,50 to 0,80	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
C45R					0,020 to 0,040					
C50E	0,47 to 0,55	0,10 to 0,40	0,60 to 0,90	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
C50R					0,020 to 0,040					
C60E	0,57 to 0,65	0,10 to 0,40	0,60 to 0,90	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
C60R					0,020 to 0,040					
28Mn6	0,25 to 0,32	0,10 to 0,40 <sup>c</sup>	1,30 to 1,65	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
36Mn6	0,33 to 0,40	0,10 to 0,40 <sup>c</sup>	1,30 to 1,65	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
42Mn6	0,39 to 0,46	0,10 to 0,40 <sup>c</sup>	1,30 to 1,65	0,025	0,035	0,40	0,10	0,40	0,30	Cr+Mo+Ni: 0,63
Alloy steels for quenching and tempering										
34Cr4	0,30 to 0,37	0,10 to 0,40 <sup>c</sup>	0,60 to 0,90	0,025	0,035	0,90 to 1,20	-	-	0,40	-
34CrS4					0,020 to 0,040					
37Cr4	0,34 to 0,41	0,10 to 0,40 <sup>c</sup>	0,60 to 0,90	0,025	0,035	0,90 to 1,20	-	-	0,40	-
37CrS4					0,020 to 0,040					
41Cr4	0,38 to 0,45	0,10 to 0,40 <sup>c</sup>	0,60 to 0,90	0,025	0,035	0,90 to 1,20	-	-	0,40	-
41CrS4					0,020 to 0,040					
Elements not quoted 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 should be taken to prevent the addition, from scrap or other material used in manufacture, of such elements which affect the hardenability, mechanical properties and applicability.										
<sup>a</sup> Maximum values unless indicated otherwise.										
<sup>b</sup> Steels with improved machinability either by higher sulfur levels up to about 0,10 % S (including controlled sulphide morphology) or lead additions may be available on request. In the first case, the upper limit of the Mn-content may be increased by 0,15 %.										
<sup>c</sup> Steels may be supplied with a lower silicon content. In this case, alternative means of deoxidation shall be used.										