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

### Part 1: Non-alloy steels for quenching and tempering

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

*Partie 1: Aciers non alliés pour trempe et revenu*

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## Foreword

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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 documents 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)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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For an explanation on 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 the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 4, *Heat treatable and alloy steels*.

This third edition cancels and replaces the second edition (ISO 683-1:2012), of which constitutes a minor revision.

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

- *Part 1: Non-alloy steels for quenching and tempering*
- *Part 2: Alloy steels for quenching and tempering*
- *Part 3: Case-hardening steels*
- *Part 4: Free-cutting steels*
- *Part 5: Nitriding steels*
- *Part 14: Hot-rolled steels for quenched and tempered springs*
- *Part 15: Valve steels for internal combustion engines*
- *Part 17: Ball and roller bearing steels*
- *Part 18: Bright steel products*

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

## Part 1: Non-alloy steels for quenching and tempering

### 1 Scope

This part of ISO 683 specifies the technical delivery requirements for

- semi-finished products, hot formed, e.g. blooms, billets, slabs (see Note 1),
- bars (see Note 1),
- wire rod,
- finished flat products, and
- hammer or drop forgings (see Note 1)

manufactured from the direct hardening non-alloy steels and the non-alloy flame- and induction-hardening steels listed in [Table 3](#) and supplied in one of the heat-treatment conditions given for the different types of products in [Table 1](#) and in one of the surface conditions given in [Table 2](#).

The steels are, in general, intended for the manufacture of quenched and tempered or austempered (see [3.2](#) and Note 2) and flame- or induction-hardened machine parts (see [Tables 9](#) and [11](#)), but can also be partly used in the normalized condition (see [Table 10](#)).

The requirements for mechanical properties given in this part of ISO 683 are restricted to the sizes given in [Tables 9](#) and [10](#).

NOTE 1 Hammer-forged semi-finished products (blooms, billets, slabs, etc.), seamless rolled rings and hammer-forged bars are, in the following covered under semi-finished products or bars and not under the term “hammer and drop forgings”.

NOTE 2 For the purposes of simplification, the term “quenched and tempered” is, unless otherwise indicated, used in the following also for the austempered condition.

NOTE 3 For International Standards relating to steels complying with the requirements for the chemical composition in [Table 3](#), however, supplied in other product forms or treatment conditions than given above or intended for special applications, and for other related International Standards, see the Bibliography.

NOTE 4 This part of ISO 683 does not apply to bright products and bars and wire rod for cold heading. For such products, see ISO 683-18 and ISO 4954.

In special cases, variations in these technical delivery requirements or additions to them can form the subject of an agreement between the manufacturer and purchaser at the time of enquiry and order (see [5.2](#) and [Annex B](#)).

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

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 404:2013, *Steel and steel products — General technical delivery requirements*

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

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

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

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

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/TS 4949, *Steel names based on letter symbols*

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 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)*

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

ISO 6929, *Steel products — Vocabulary*

ISO 7788, *Steel — Surface finish of hot-rolled plates and wide flats — Delivery requirements*

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

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

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

ISO 18265, *Metallic materials — Conversion of hardness values*



### 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, and ISO 14284 and the following apply.

NOTE For deviations from these terms and definitions, see Notes 1 and 2 of [Clause 1](#).

#### 3.1 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.

#### 3.2 austempering

heat treatment for producing ADI cast iron, involving austenitizing followed by isothermal tempering at a temperature above  $M_s$  to ensure partial transformation of the austenite to ferrite

Note 1 to entry: The final cooling to ambient temperature is not at a specific rate.

[SOURCE: ISO 4885:1996, 3.11, modified]

#### 3.3 non-alloy steel

non-alloy steel as defined in ISO 4948-1:1982, 3.1.2

### 4 Classification and designation

#### 4.1 Classification

The classification of the relevant steel grades is according to ISO 4948-1 and ISO 4948-2. Steel grades C25, C35, C40, C45, C50, C55 and C60 are non-alloy quality steels. All other steel grades covered by this part of ISO 683 are non-alloy special steels.

#### 4.2 Designation

For the steel grades covered by this part of ISO 683, the steel names, as given in the relevant tables, are allocated in accordance with ISO/TS 4949.

### 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 to be delivered;
- b) designation of the product form (slab, bloom, billet, round bar, wire rod, wide flat, sheet, plate, strip, forging, etc.)
- c) either the designation of the dimensional standard and the dimensions and tolerances selected from this (see [7.9](#)) or, for example in the case of drop forgings, the designation of the drawing or any other document covering the dimensions and tolerances required for the product;
- d) reference to this part of ISO 683, i.e. ISO 683-1;

- e) designation of the steel grade, as given in [Table 3](#);
- f) standard designation for a test report 2.2 or, if required, any other type of inspection document in accordance with ISO 10474 or another standard (e.g. regional standards EN 10204 or JIS G 0415).

## 5.2 Options and/or supplementary or special requirements

Several options are specified in this part of ISO 683 and listed below. If the purchaser does not indicate any of these options, the products will be supplied in accordance with the basic specifications defined in this part of ISO 683 (see [5.1](#)):

- a) if a heat-treatment condition other than the untreated condition is required, the symbol for this other condition (see [Table 1](#), column 2);
- b) if another surface condition than “hot worked” or a special surface quality is required, the surface condition (see [Table 2](#)) and the surface quality (see [7.7](#));
- c) any requirement for the hardenability (+H, +HH, +HL) for special steels (see [7.1.4](#) and [Tables 5 to 7](#));
- d) any supplementary requirement that shall be complied with, the symbol and, where necessary, the details of this supplementary requirement (see [Annex B](#));
- e) any requirement for the verification of non-metallic inclusion content (see [7.5](#));
- f) verification of hardenability and, if agreed, the information about calculation of the hardenability (see [9.3.2](#));
- g) any requirement regarding the permissible depth of decarburization (see [7.8](#));
- h) suitability of bars and rod for bright drawing (see [7.7.4](#));
- i) any requirement relating to the removal of surface defects (see [7.7.5](#));
- j) hardness testing instead of tensile testing for normalized finished flat products in thicknesses >10 mm for plates or >100 mm for bars (see [7.1.3](#)) (in this case, hardness limits should be agreed).

## 5.3 Ordering example

EXAMPLE Fifty hot-rolled round bars according to ISO 1035-1 with a nominal diameter of 40 mm and a nominal length of 8 000 mm, with diameter tolerance according to class S and with length tolerance according to class L2 of ISO 1035-4 made of steel grade ISO 683-1, C45E (see [Table 3](#)) in the heat treatment condition +N (see [Table 1](#)), surface blast cleaned (+BC) (see [Table 2](#)), product analysis/option [B.5](#) with an inspection certificate 3.1 according to ISO 10474:

**50 round bars ISO 1035 – 40,0S × 8 000L2**

**ISO 683-1 – C45E+N+BC option B.5**

**ISO 10474 – 3.1**

## 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](#) to [6.4](#) left to the discretion of the manufacturer.

For minimum reduction ratio or minimum thickness deformation ratio of rolled and forged products, see [B.6](#).

## 6.2 Deoxidation

All steels shall be deoxidized.

## 6.3 Heat-treatment condition and surface condition at delivery

### 6.3.1 Normal condition at delivery

Unless otherwise agreed at the time of enquiry and order, the products shall be delivered in the untreated, i.e. hot-worked condition.

### 6.3.2 Particular heat-treatment condition

If so agreed at the time of enquiry and order, the products shall be delivered in one of the heat-treatment conditions given in [Table 1](#), lines 3 to 7.

### 6.3.3 Particular surface conditions

If so agreed at the time of enquiry and order, the products shall be delivered in one of the particular surface conditions given in [Table 2](#), lines 3 to 6.

## 6.4 Traceability of the cast

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

## 7 Requirements

### 7.1 Chemical composition, mechanical properties and hardenability

#### 7.1.1 General

[Table 1](#) shows the combinations of usual heat-treatment conditions at delivery, product forms and requirements as specified in [Tables 3](#) to [11](#).

Except where steels are ordered in the quenched and tempered condition, this part of ISO 683 makes for the steel types 23Mn6, 28Mn6, 36Mn6 and 42Mn6, and for the non-alloy special steels with carbon contents equal to or higher than the contents of type C35 provisions to be supplied with or without hardenability requirements (see [Table 1](#), columns 8 and 9).

#### 7.1.2 Chemical composition

The chemical composition determined by cast analysis shall comply with the values in [Table 3](#).

Permissible deviations between the limiting values for cast analysis and the values for product analysis are given in [Table 4](#).

The product analysis shall be carried out when specified at the time of the enquiry and order (see [B.5](#)).

#### 7.1.3 Mechanical properties

Where the steel is ordered without hardenability requirements, the requirements for mechanical properties specified in [Tables 8](#), [9](#) or [10](#) apply as appropriate for the particular heat-treatment condition.

In this case, the hardenability values given in [Table 5](#) for special steels are for guidance purposes only.

The mechanical property values given in [Tables 9](#) and [10](#) apply to test pieces in the quenched and tempered or normalized condition, which have been taken and prepared in accordance with [Figure 2](#) or [Figures 3](#) and [4](#) (see also footnote a to [Table 1](#)).

For steel plates of thickness >10 mm and bars >100 mm in diameter in the normalized condition (+N), it may be agreed at the time of enquiry and order that instead of the tensile test, the hardness test is performed at the same region where the sample for the tensile test piece would be taken from. The hardness test should be performed and, from this, the tensile strength values can be calculated according to ISO 18265. The calculated tensile strength shall comply with [Table 10](#).

#### 7.1.4 Hardenability

Where the steel is ordered using the designations given in [Table 5](#), [6](#) or [7](#) to normal (see [Table 5](#)) or to narrowed (see [Tables 6](#) and [7](#)) hardenability requirements, the values of hardenability given in [Table 5](#), [6](#) or [7](#), respectively, apply in addition to the requirements cited in [Table 1](#), columns 9.1 and 9.2 (see footnote b to [Table 3](#)).

#### 7.1.5 Surface hardness

For the surface hardness of special steels after flame or induction hardening, the specifications in [Table 11](#) apply.

#### 7.2 Machinability

All steels are machinable in the condition "soft annealed". Where improved machinability is required, grades with a specified sulfur range and/or with a specific treatment should be ordered to improve machinability (see also [Table 1](#), line 7).

#### 7.3 Cold shearability

**7.3.1** 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 cold shearable in the soft annealed (+A) condition.

**7.3.2** Steel grades C45, C50, C55, C60, 28Mn6, 36Mn6 and 42Mn6 and the corresponding E-, R-, +H-, +HH- and +HL grades (see [Tables 3](#) and [5](#) to [7](#)) are, under suitable conditions, also cold shearable when being delivered in the condition "treated to improve shearability (+S)" with the hardness requirements given in [Table 8](#).

**7.3.3** Steels C25, C30, C35, C40 and 23Mn6 and the corresponding E-, R-, +H-, +HH- and +HL-grades (see [Tables 3](#) and [5](#) to [7](#)) are, under suitable conditions, cold shearable when being delivered in the untreated condition.

Cold shearability may also be assumed for the various grades of steel C45, in sizes of 80 mm and greater in the untreated condition.

#### 7.4 Grain size

Unless otherwise agreed at the time of enquiry and order, the grain size shall be left to the discretion of the manufacturer. If a fine grain structure is required in accordance with a reference treatment, special requirement [B.3](#) shall be ordered.

If steels C35E, C35R, C45E, C45R, C50E, C50R, C55E and C55R are intended for flame or induction hardening, special requirement [B.3](#) shall be ordered in any case.