INTERNATIONAL STANDARD

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

Part 3: Case-hardening steels

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

Partie 3: Aciers pour cémentation

Reference number
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Contents

Page

Foreword ... **v**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms and definitions ... **2**

4 Classification and designation ... **2**
4.1 Classification ... 2
4.2 Designation ... 3

5 Information to be supplied by the purchaser ... **3**
5.1 Mandatory information ... 3
5.2 Options and/or supplementary or special requirements ... 3
5.3 Ordering example ... 3

6 Manufacturing process ... **4**
6.1 General ... 4
6.2 Deoxidation ... 4
6.3 Heat-treatment condition and surface condition at delivery ... 4
6.3.1 Normal condition at delivery ... 4
6.3.2 Particular heat-treatment condition ... 4
6.3.3 Particular surface conditions ... 4
6.4 Traceability of the cast ... 4

7 Requirements ... **4**
7.1 Chemical composition, hardness and hardenability ... 4
7.1.1 General ... 4
7.1.2 Hardenability ... 5
7.1.3 Chemical composition ... 5
7.2 Machinability ... 5
7.3 Cold shearability ... 5
7.4 Grain size ... 5
7.5 Non-metallic inclusions ... 6
7.5.1 Microscopic inclusions ... 6
7.5.2 Macroscopic inclusions ... 6
7.6 Internal soundness ... 6
7.7 Surface condition ... 6
7.8 Shape, dimensions and tolerances ... 6

8 Inspection ... **7**
8.1 Testing procedures and types of documents ... 7
8.2 Frequency of testing ... 7
8.3 Tests to be carried out for specific inspection ... 7
8.3.1 General ... 7
8.3.2 Visual and dimensional inspection ... 7

9 Test methods ... **8**
9.1 Chemical analysis ... 8
9.2 Hardness and hardenability tests ... 8
9.2.1 Verification of hardness ... 8
9.2.2 Verification of hardenability ... 8
9.3 Retests ... 8

10 Marking ... **8**

Annex A (normative) **Supplementary or special requirements** ... **31**

Annex B (informative) **Designation of steels given in this document and of comparable grades covered in various designation systems** ... **33**

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Annex C (informative) **Classification of steel grades according to minimum tensile strength as a function of diameter after hardening and tempering at 200 °C** **35**

Bibliography **36**

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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 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).

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).

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.

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

This fourth edition cancels and replaces the third edition (ISO 683-3:2019), which has been technically revised. The main changes are as follows:

— steel grades 23MnCrMo5-5-4 and 17NiCrMoS6-4 have been added;

— the lower silicon content in Table 3 has been deleted and replaced by a new option in Clause A.4.

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.

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

Part 3: Case-hardening steels

1 Scope

This document 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 case-hardening non-alloy or alloy 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 case-hardened machine parts.

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

NOTE 2 For International Standards relating to steels conforming 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.

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 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 642:1999, *Steel — Hardenability test by end quenching (Jominy test)*

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

ISO 4885, *Ferrous materials — 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*

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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*

ISO 6929, *Steel products — Vocabulary*

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

ISO 9443, *Surface quality classes for hot-rolled bars and wire rod*

ISO/TR 9769, *Steel and iron — Review of available methods of analysis*

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.

NOTE For deviations from these terms and definitions, see NOTE 1 of the Scope and footnote b of Table 2.

ISO and IEC maintain terminological 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
case-hardening steel
steel with a relatively low carbon content, which are carburized or carbonitrided on their surface and subsequently hardened

Note 1 to entry: These steels, after hardening, have a high degree of hardness in the surface zone and good resistance to wear, while the core material is characterized principally by extreme toughness.

Note 2 to entry: Further possibilities for heat treatment of case-hardening steels are, for example, nitrocarburizing and nitriding.

3.2
non-alloy steel
as defined in ISO 4948-1

3.3
alloy steel
as defined in ISO 4948-1

4 Classification and designation

4.1 Classification

The classification of the relevant steel grades is in accordance with ISO 4948-1 and ISO 4948-2. Steel grades C10E, C10R, C15E, C15R, C16E, C16R and 22Mn6 are non-alloy special steels. All other steel grades covered by this document are alloy special steels.

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4.2 Designation

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

A comparison between the designation of steels given in this document with various designation systems is given in Annex B.

5 Information to be supplied by the purchaser

5.1 Mandatory information

The following information shall be supplied by 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, square or hexagonal bar, wire rod, wide flats, sheet, plate, strip, forging, etc.);

c) either the designation of the dimensional standard(s) and the dimensions and tolerances selected from this or these (see 7.8) 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) a reference to this document, i.e. ISO 683-3;

e) the designation of the steel type 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 equivalent standard, e.g. EN 10204 or JIS G 0415.

5.2 Options and/or supplementary or special requirements

A number of options are specified in this document and listed below. If the purchaser does not indicate the wish to implement any of these options, the products are supplied in accordance with the basic specifications of this document (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 a surface condition other than “hot worked” or a special surface quality is required, the surface condition (see Table 2) and the surface quality (see 7.7.3);

c) any requirement for restricted hardenability scatter bands for alloy steels (+HH, +HL; see 7.1.1, Table 6 and Figure 1);

d) if any supplementary requirement shall be complied with, the symbol and, where necessary, the details of this supplementary requirement in accordance with Annex A;

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 9.2.2);

g) any requirement concerning suitability of bars and rod for bright drawing (see 7.7.4);

h) any requirement relating to removal of surface defects (see 7.7.5).

5.3 Ordering example

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EXAMPLE 50 hot-rolled round bars in accordance with 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 683-3, 20MnCr5 (see Table 3) in the heat-treatment condition annealed (+A), surface blast cleaned (+BC) (see Table 2), product analysis/option A.3 with an inspection certificate 3.1 in accordance with ISO 10474.

50 Round bars ISO 1035 – 40,0S × 8 000L2
ISO 683-3 – 20MnCr5+A+BC, Option A.3
ISO 10474 – 3.1

6 Manufacturing process

6.1 General

The manufacturing process of the steel and of the products is left to the discretion of the manufacturer, with the restrictions given by the requirements in 6.2 and 6.4.

For minimum reduction ratio or minimum thickness deformation ratio of rolled and forged products, see Clause A.5.

6.2 Deoxidation

All steels shall be fully 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 condition, 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, row numbers 3 to 8.

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, row numbers 3 to 6.

6.4 Traceability of the cast

The products shall be traceable to the cast, see Clause 10.

7 Requirements

7.1 Chemical composition, hardness and hardenability

7.1.1 General

Table 1 gives a survey on combinations of usual heat-treatment conditions at delivery, product forms and requirements as specified in Tables 3 to 7 (chemical composition, hardenability, maximum hardness and hardness range).

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

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

7.1.2 Hardenability

Unless otherwise agreed for alloy steels, the hardenability requirements given in Table 5 apply. If agreed at the time of enquiry and order, alloy steels with restricted hardenability scatter bands given in Table 6 or shown in Figure 1 shall be supplied.

A classification of steel grades according to minimum tensile strength as a function of diameter after hardening and tempering is given in Annex C.

7.1.3 Chemical composition

The chemical composition determined by cast analysis shall conform 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 Clause A.3).

7.2 Machinability

All steels are machinable in the conditions “soft-annealed”, “treated to hardness range”, “treated to ferrite/pearlite structure” and “normalized”.

Lowering the silicon content can have a negative influence on the machinability. For details on a minimum silicon content, see Clause A.4.

Where improved machinability is required, the grades with a specified sulfur range should be ordered and/or with a specific treatment to improve machinability (see also Table 3, footnote b).

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 condition “soft-annealed”.

7.3.2 Under suitable conditions, steel grades 28Cr4, 28CrS4, 20MnCr5, 20MnCrS5, 24CrMo4, 24CrMoS4, 22CrMoS3-5, 20MoCr4, 20MoCrS4, 16NiCr4, 16NiCrS4, 18NiCr5-4, 17CrNi6-6, 15NiCr13, 17NiCrMo6-4, 23MnCrMo5-5-4 and 18CrNiMo7-6, are also cold shearable when delivered in the condition “treated to improve shearability” with the hardness requirements given in Table 7.

7.3.3 Under suitable conditions, the non-alloy steels and steels 17Cr3, 17CrS3, 20Cr4, 20CrS4, 16MnCr5, 16MnCrS5, 16MnCrB5, 18CrMo4, 18CrMoS4, 20NiCrMo2-2 and 20NiCrMoS2-2 are cold shearable when delivered in the untreated condition.

7.4 Grain size

Unless otherwise agreed at the time of enquiry and order, the steel shall show a fine grain structure with an austenitic grain size of 5 and finer, when tested in accordance with ISO 643. For verification, see Clause A.1.

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7.5 Non-metallic inclusions

7.5.1 Microscopic inclusions

The special steels shall have a certain degree of cleanness. 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 microscopic non-metallic inclusion content shall be determined to an agreed procedure and within agreed limits in accordance with ISO 4967 or another equivalent standard.

For grades with specified minimum sulfur content, the agreement should not include sulfides.

7.5.2 Macroscopic inclusions

This requirement is applicable to the verification of the macroscopic inclusions in special steels. If verification is agreed, the method and acceptance limits shall be agreed at the time of enquiry and order.

7.6 Internal soundness

Where appropriate, requirements relating to the internal soundness of the products shall be agreed at the time of inquiry and order (see Clause A.2).

7.7 Surface condition

7.7.1 All products shall have a smooth surface finish appropriate to the manufacturing processes applied.

7.7.2 Minor surface imperfections which can occur under normal manufacturing conditions, such as prints originating from rolled-in scale, shall not be regarded as defects.

7.7.3 Bars and wire rod are delivered with surface class A in accordance with ISO 9443 and hot-rolled plates and wide flats shall be delivered with a surface in accordance with ISO 7788, unless otherwise agreed at the time of enquiry and order.

Where no International Standard on the surface quality of steel products exists, and where appropriate, detailed requirements referring to this characteristic shall be agreed at the time of enquiry and order.

It is more difficult to detect and eliminate surface discontinuities from coiled products than from cut lengths. This should be taken into account when agreements on surface quality are made.

NOTE Bars and wire rod for cold heading and cold extrusion are covered fully by ISO 4954.

7.7.4 If suitability of bars and rod for bright drawing is required, this shall be agreed at the time of enquiry and order.

7.7.5 Removal of surface discontinuities by welding shall only be permitted with the approval of the customer or his or her representative. If surface discontinuities are repaired, the method and maximum depth of removal shall be agreed at the time of enquiry and order.

7.8 Shape, dimensions and tolerances

The nominal dimensions, tolerances on dimensions and shape of the product shall be agreed at the time of enquiry and order, if possible, with reference to the dimensional standards listed in the Bibliography.

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8 Inspection

8.1 Testing procedures and types of documents

8.1.1 Products complying with this document shall be ordered and delivered with one of the inspection documents as specified in ISO 10474 or another equivalent standard, e.g. EN 10204 or JIS G 0415. The type of document shall be agreed at the time of enquiry and order. If the order does not contain any specification of this type, a test report 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 is to be provided, this shall cover the following information:

a) confirmation that the material complies with the requirements of the order;

b) results of the cast analysis for all elements specified in Table 3 for the steel grade concerned.

8.1.3 If, in accordance with the agreements in the order, an inspection certificate 3.1 or 3.2 is to 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 the following:

a) confirmation that the material complies with the requirements of the order;

b) results of the cast analysis for all elements specified in Table 3 for the steel grade concerned;

c) results of all inspections and tests ordered by supplementary requirements (see Annex A);

d) the symbol, letters or numbers relating the test certificates, the 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 Table 9.

8.3 Tests to be carried out for specific inspection

8.3.1 General

For non-alloy steels and for alloy steels without requirements concerning the verification of hardenability, the hardness requirements according to Table 1, columns 8.2 and 9.2 and Table 7 shall be verified.

For alloy steels being ordered with the verification of hardenability, only the hardenability requirements according to Tables 5 and 6 shall be verified, unless otherwise agreed.

8.3.2 Visual and dimensional inspection

The extent of the products to be inspected to ensure compliance with this document is at the manufacturer's discretion.

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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 case of dispute, the method 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 Hardness and hardenability tests

9.2.1 Verification of hardness

For products in the heat-treatment conditions +S (treated to improve shearability), +A (soft-annealed), +TH (treated to hardness range), +FP (treated to ferritic-pearlitic structure) and +N (normalized), the hardness shall be measured in accordance with ISO 6506-1 (see Tables 7 and 9).

9.2.2 Verification of hardenability

For alloy steels, as far as available, the manufacturer has the option to verify the hardenability by calculation. The calculation method is left to the discretion of the manufacturer. If agreed at the time of enquiry and order, the manufacturer shall give information about the calculation for the customer to confirm the result.

If a calculation formula is not available or in case of dispute, an end quench hardenability test shall be carried out in accordance with ISO 642 and Table 9. The temperature for quenching shall conform with Table 8. The hardness values shall be determined in accordance with ISO 6508-1 scale C.

9.3 Retests

Retests of case hardening steels and criteria shall 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 it is possible to identify the cast, steel type and origin of the delivery (see Clause A.6).

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