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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

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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 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.

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

This second edition cancels and replaces the first edition (ISO 683-3:2014), of which it 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*

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

Part 3: Case-hardening steels

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 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 (see 3.1) machine parts.

NOTE 1 Hammer-forged semi-finished products (blooms, billets, slabs, etc.), seamless rolled rings and hammer-forged 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 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.

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

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

3 Terms and definitions

For the purposes of this document, the definitions of 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 a of Table 2.

3.1
case-hardening steels
structural steels 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 according to 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 part of ISO 683 are 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 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 or square bar, wire rod, wide flats, sheet, plate, strip, forging, etc.);

c) either the designation of the dimensional standard and the dimensions and tolerances selected from this (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 part of ISO 683, 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 according to another regional 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 International Standard and listed below. If the purchaser does not indicate the wish to implement any of these options, the products will be supplied in accordance with the basic specifications of 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 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 (see 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

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, 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 A.4.

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 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, lines 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, lines 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).

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.

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 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.

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 c).

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

7.3.3 The non-alloy steels and steels 17Cr3, 17CrS3, 20Cr4, 20CrS4, 16MnCr5, 16MnCrS5, 16MnCrB5, 18CrMo4, 18CrMoS4, 20NiCrMo2-2 and 20NiCrMoS2-2 are, under suitable conditions, 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 A.1.

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 standard, e.g. regional standards EN 10247 or JIS G 0555.

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

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 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 may occur under normal manufacturing conditions, such as prints originating from rolled-in scale, are not to be regarded as defects.

7.7.3 Bars and wire rod are delivered with surface class 1za2 according to ISO 9443 and hot-rolled plates and wide flats shall be delivered with a surface according to ISO 7788, unless otherwise agreed at the time of enquiry and order.

Where no International Standard on the surface quality of steel products exists, detailed requirements referring to this characteristic shall, where appropriate, 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/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 applicable (see Annex C).

8 Inspection

8.1 Testing procedures and types of documents

8.1.1 Products complying with this part of ISO 683 shall be ordered and delivered with one of the inspection documents as specified in ISO 10474 or another standard, e.g. regional standards EN 10204 or JIS G 0415. 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 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 are to be verified.

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

8.3.2 Visual and dimensional inspection

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

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 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 sufficient information about the calculation for the customer to confirm the result.