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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

ICS: 77.140.45; 77.140.10; 77.140.20

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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 edition cancels and replaces the third edition (ISO 683-18:2014), which has been technically revised.

The main changes compared to the previous edition are as follows:

- Standard was split into two parts: ISO 683-6 for non-alloy and alloy steels and ISO 16143-4 for stainless steels.

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.

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;

This document lists the mechanical characteristics for products up to 100 mm in thickness. For larger dimensions, the manufacturer and purchaser agree on mechanical properties at the time of enquiry and order.

Bright products of stainless steels are not part of this standard, 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*

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

ISO 6929, *Steel products — Vocabulary*

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*

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3 Terms and definitions (standards.iteh.ai)

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 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 bright products

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

3.2 drawn products

products of various cross-sectional shapes obtained, after descaling, by cold drawing of hot-rolled bars or rod, 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 products

round bars 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**ground products**

drawn or peeled/turned round bars 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' has to be defined at the time of enquiry and order.

3.6**out-of round**

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

3.7**ruling section**

that section for which the specified mechanical properties shall 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.

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;
- b) shape of the product (e. g. round, hexagon, square, flat);
- c) the dimensions and tolerances of the product, see [7.10](#) and [Tables 2](#) and [11](#) to [13](#);

- d) reference to this part of ISO 683, i.e ISO 683-6;
- e) the designation of the steel grade and the delivery condition (see [Tables 4](#) to [10](#));
- 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 part of ISO 683 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) Reference testing for products used in the quenched and tempered condition (for steels for quenching and tempering only, see [Table 1](#), 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 15](#) 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 2](#));
- k) surface quality class if another than the standard class is requested (see [7.11](#) and [Table 3](#));
- l) verification of the straightness (see [7.10](#), [Table 14](#), [Table 15](#) 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 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 standard 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 683-6 - 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 must comply with the condition agreed in the order and shall be one of the conditions indicated in Table 1.

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 Particular surface conditions

Table 2 shows the possible surface conditions and tolerance classes according to ISO 286-2 at delivery.

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 1.

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

7.2 Chemical composition

The chemical composition of the steels determined by the cast analysis, shall comply to 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 listed for information in Annex A for ISO 630-2, ISO 683-1, ISO 683-2, ISO 683-3 and ISO 683-4.

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 according to 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, Table 3, footnote a.

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 condition in [Table 1](#), the requirements for mechanical properties specified in [Tables 4](#) to [10](#) apply. The mechanical property values given in [Tables 4](#) to [10](#) apply to test pieces which have been taken and prepared in accordance with [Figure 1](#).

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 is to be performed if mentioned in the tables of mechanical properties for the condition +QT+SH. For cold drawn bars (+C, +C+G, +C+PL) an impact test is not to 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 this [Tables 4](#) to [10](#), 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 hardenability requirements given in ISO 683-3, Table 5 apply. If agreed at the time of enquiry and order, alloy case-hardening steels with restricted hardenability scatterbands given in ISO 683-3, Table 6 shall be supplied and these values apply in addition to [Table 1](#), columns 6 and 7.

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 apply in addition to [Table 1](#), columns 8 and 9.

NOTE In [Tables 8](#) to [10](#), 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

All steels are machinable in the conditions 'soft annealed' (+A) and treated to ferrite/pearlite structure (+FP).

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](#), Option [C.3](#) shall be ordered.

NOTE 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. Only for verification see [C.3](#).

7.7 Non-metallic inclusions

7.7.1 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 microscopically non-metallic inclusion content shall be determined to an agreed procedure and within agreed limits (see ISO 4967 or another regional standard: i.e. EN 10247 or JIS G 0555)

NOTE 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

Where appropriate, requirements relating to the internal soundness of the products shall 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 comply with the requirements agreed at the time of enquiry and order and shall be in accordance with [Table 2](#). If there is no agreement on the tolerance class the bright products are delivered with the standard tolerance class given in [Table 2](#). The tolerance class and the corresponding tolerances are given in [Table 11](#) for rounds, squares and hexagons and in [Table 12](#) for drawn flats. Where specified by the purchaser at the time of enquiry and order the disposition tolerances specified in [Table 11](#) 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 13](#).

Maximum deviation from 'out of roundness' shall be not more than half the specified tolerance range in any case never above the upper limit of the tolerance.

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](#) and the tolerances specified in [Table 14](#) and [Table 15](#) shall apply.

Non-round bars (i.e. square, hexagon and flat) in widths ≤ 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 according to [Table 3](#). 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 complying with this part of ISO 683 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. <https://standards.iteh.ai/catalog/standards/sist/0c356b2d-a9f2-4b6f-a44b-887a0844b6f6/iso-fdis-683-7>

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 [Tables A.1](#) to [A.4](#) 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](#) to ISO 10474 is to be provided, the specific inspections and tests described in [8.3](#) and [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 complies with the requirements of the order;
- b) results of the cast analysis for all elements specified in [Table A.1](#) to [A.4](#) for the steel grade 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 16](#).

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 1](#), the hardness requirements or mechanical properties, shall, with the following exception, be verified. The requirements given in [Table 1](#), footnote d (mechanical properties of reference test pieces), is only to be verified if 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 according to ISO 683-1, ISO 683-2 and ISO 683-3 are to be verified.

8.3.2 Visual and dimensional inspection

A sufficient number of products are to be inspected to ensure the compliance 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;

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.

NOTE 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 standard, 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 404:2013, 8.3.4.2.

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