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

Part 4: Free-cutting steels

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

Partie 4: Aciers pour décolletage

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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).

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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.

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 683-4:2014), 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 4: Free-cutting steels

1 Scope

This part of ISO 683 gives the technical delivery requirements for semi-finished products (e.g. blooms, billets, slabs), bars and wire rod, manufactured from the free-cutting steels listed in [Table 2](#) and supplied in one of the treatment conditions given for the different types of products in [Table 1](#), rows 2 to 4.

This part of ISO 683 covers three groups of free-cutting steels for mechanical purposes as listed in [Table 2](#), namely

- a) not intended for heat treatment,
- b) suitable for case-hardening, and
- c) suitable for quenching and tempering.

Free-cutting steels are often used as bright bars. For these products, refer to ISO 683-18.

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 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 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 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 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 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 terms and definitions given in ISO 377, ISO 4885, ISO 4948-1, ISO 4948-2, ISO 6929, ISO 14284 and the following apply.

3.1 ruling section

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.

3.2 free-cutting steels

steels characterized by good machinability with high metal removal rate, mostly obtained by higher than normal contents of sulphur.

Note 1 to entry: Other elements besides sulfur can be added for further improving the machinability.

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. All steels covered by this part of ISO 683 are classified as non-alloy quality steels.

4.2 Designation

For the steel grades covered by this part of ISO 683, 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) the quantity to be delivered;
- b) the designation of the product form (e.g. slab, bloom, billet, round bar, wire rod);
- c) either the designation of the dimensional standard and the dimensions and tolerances selected from this (see 7.7) or 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 683-4);

- e) the designation of the steel grade given in [Table 2](#);
- 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 specification 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) Any supplementary requirement that shall comply with the symbol and, where necessary, the details of this supplementary requirement (see [Annex B](#)).
- c) Suitability of bars and rod for bright drawing (see [7.6.4](#)).
- d) Any requirement relating to removal of surface defects (see [7.6.5](#)).

5.3 Ordering example

EXAMPLE 50 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 ISO 1035-4, class L2, made of steel grade ISO 683-4, 35S20 (see [Table 2](#)) in the heat-treatment condition +U (see [Table 1](#)), product analysis/option (see [B.5](#)) with a test report 2.2 in accordance with ISO 10474.

**50 round bars ISO 1035 – 40,0S × 8 000L2
steel grade ISO 683-4 – 35S20 option B.5
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 [B.6](#).

6.2 Heat treatment and surface condition at delivery

6.2.1 Normal condition at delivery

Unless otherwise agreed at the time of enquiry and order, the products shall be delivered in the untreated condition that means “as hot-worked”.

6.2.2 Particular heat-treatment condition

If so agreed at the time of enquiry and order, the products shall be delivered in one of the particular heat-treatment conditions given in [Table 1](#), rows 3 and 4.

6.3 Traceability of the cast

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

7 Requirements

7.1 Chemical composition, hardness, and mechanical properties

7.1.1 General

[Table 1](#) gives a survey of combinations of usual treatment conditions at delivery, product forms, and requirements according to [Tables 2](#) to [6](#) (chemical composition, maximum hardness, mechanical properties).

7.1.2 Chemical composition

The chemical composition determined by cast analysis shall comply with the values in [Table 2](#).

Permissible deviations between the limiting values for cast analysis and the values for product analysis are given in [Table 3](#).

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

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

7.1.3 Mechanical properties

Mechanical properties for free-cutting steels are given in [Tables 4](#) to [6](#).

7.2 Machinability

The steels covered by this part of ISO 683 have good machinability and chip-breaking characteristics. However, the machinability decreases with increasing carbon, silicon and manganese contents, while cold reduction improves the machinability of the steels not intended for heat treatment and steel 10S20.

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

7.3 Weldability

Because of their high sulfur and phosphorus content, free-cutting steels are normally not recommended for welding.

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 for case-hardening steels or steels for quenching and tempering, the special requirement in [B.3](#) shall be ordered.

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

7.5 Internal soundness

Where appropriate, requirements relating to the internal soundness of the products shall be agreed at the time of enquiry and order (see [B.4](#)).

7.6 Surface quality

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

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

7.6.3 Bars and wire rod are delivered with surface class 1za2 according to ISO 9443, unless otherwise agreed at the time of enquiry and order.

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

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

7.6.5 The removal of surface defects by welding is not permitted.

If surface discontinuities are repaired, the method and maximum depth of removal shall be agreed at the time of enquiry and order.

7.7 Shape, dimensions, and tolerances

The shape, dimensions, and tolerances of the products shall comply with the requirements agreed at the time of enquiry and order. The agreements shall, as much as possible, be based on corresponding International Standards (see [Annex D](#)), or otherwise on suitable national standards.

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.

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 of the concerned cast for all elements specified in [Table 2](#) for the steel grade.

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 [8.2](#), [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 of the concerned cast for all elements specified in [Table 2](#) for the steel grade;

- c) the result of all inspections and tests ordered by supplementary requirements (see [Annex B](#));
- 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 compliance with the requirements shall be in accordance with the prescriptions of [Table 7](#).

8.3 Specific inspection and testing

8.3.1 Verification of the hardness and mechanical properties

The hardness requirements and/or mechanical properties given for the relevant treatment condition in [Table 1](#), column 6, sub-column 6.2, shall be verified, with the following exception. The requirements given in [Table 1](#), footnote a (mechanical properties of reference test pieces), shall only be verified if the supplementary requirement given in [B.2](#), is ordered.

8.3.2 Visual and dimensional inspection

A sufficient number of products shall be inspected to ensure 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 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 Hardness and mechanical tests

9.2.1 Hardness

For products in the untreated condition, the hardness shall be measured in accordance with ISO 6506-1.

9.2.2 Mechanical tests

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

For the specified yield strength in the tables of mechanical properties in this part of ISO 683, 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.

9.3 Retests

Retests for steels for quenching and tempering and criteria are specified in ISO 404.