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BSI Standards Publication

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

Part 7: Bright products of non-alloy and alloy steels

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National foreword

This British Standard is the UK implementation of EN ISO 683-7:2024. It is identical to ISO 683-7:2023. It supersedes BS ISO 683-7:2023, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/105, Steels for Heat Treatment, Alloy Steels, Free-Cutting Steels and Stainless Steels.

A list of organizations represented on this committee can be obtained on request to its committee manager.

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31 October 2024	This corrigendum renumbers BS ISO 683-7:2023 as BS EN ISO 683-7:2024

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Aciers pour traitement thermique, aciers alliés et aciers pour décolletage - Partie 7: Produits en aciers non alliés et alliés transformés à froid (ISO 683-7:2023)

Für eine Wärmebehandlung bestimmte Stähle, legierte Stähle und Automatenstähle - Teil 7: Blankstahlerzeugnisse aus unlegierten und legierten Stählen (ISO 683-7:2023)

This European Standard was approved by CEN on 13 October 2024.

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European foreword

The text of ISO 683-7:2023 has been prepared by Technical Committee ISO/TC 17 "Steel" of the International Organization for Standardization (ISO) and has been taken over as EN ISO 683-7:2024 by Technical Committee CEN/TC 459/SC 5 “Steels for heat treatment, alloy steels, free-cutting steels and stainless steels” the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2025, and conflicting national standards shall be withdrawn at the latest by April 2025.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 10277:2018.

The main changes compared to the previous edition EN 10277:2018 are listed below:

— this standard EN ISO 683-7 is the comparable ISO standard with nearly identical content;

— editorially revised.

Any feedback and questions on this document should be directed to the users’ national standards body/national committee. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

Endorsement notice

The text of ISO 683-7:2023 has been approved by CEN as EN ISO 683-7:2024 without any modification.

The European steel numbers to the steel grades are to be found in informative Annex E.

The references to following European standards are given for information:

EN 10025-2, *Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10027-1, *Designation systems for steels - Part 1: Steel name*

EN 10027-2, *Designation systems for steels - Part 2: Numerical system*

EN 10079*, Definition of steel products*

EN 10204, *Metallic products - Types of inspection documents*

EN 10247, *Micrographic examination of the non-metallic inclusion content of steels using standard pictures*

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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 document 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).

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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 first edition of ISO 683-7, together with ISO 16143-4, cancels and replaces ISO 683-18:2014, which has been technically revised.

The main changes are as follows:

— ISO 683-18 was split into ISO 683-7 for non-alloy and alloy steels and into ISO 16143-4 for stainless steels;

— definition for out-of-round was modified with two new definitions on ovality and out-of-shape;

— editorial revision.

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 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.

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

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

ISO 6929, *Steel products — Vocabulary*

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.

ISO and IEC maintain terminology 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 product
drawn or peeled/turned product with smoother surface quality and better dimensional accuracy in comparison to hot-rolled product

3.2
drawn product
product of various cross-sectional shapes obtained, after descaling, by cold drawing of hot-rolled product, 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 product
round bar 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
product in the ground condition
ground product
drawn or peeled/turned round bar given an improved surface quality and dimensional accuracy by grinding or by grinding and polishing

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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' shall be defined at the time of enquiry and order.

3.6
ovality
difference between the smallest and largest dimension measured across the pairs of opposing points at a common cross-section

3.7
out of shape
deviation from the nominal section profile

EXAMPLE Parallelism, perpendicularity and twist.

3.8
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.

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.

NOTE Designation of steels covered by this document and of comparable grades covered in various other designation systems are given in Annex E.

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;

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b) shape of the product (e. g. round, hexagon, square, flat);

c) the dimensions and tolerances of the product, see 7.10, Table 3 and Tables 12 to 14;

d) a reference to this document, i.e. ISO 683-7:2023;

e) the designation of the steel grade and the delivery condition (see Tables 5 to 11);

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 document and listed below.

a) reference testing for products used in the quenched and tempered condition (for steels for quenching and tempering only (see Table 2, 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 1 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 3);

k) surface quality class if another than the standard class is requested (see 7.11 and Table 4);

l) verification of the straightness (see 7.10, Table 15, Table 16 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 Ordering 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 document 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 683-7 - C45+C

Inspection document ISO 10474 - 2.2

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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 shall conform with the condition agreed in the order and shall be one of the conditions indicated in Table 2.

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 Surface conditions

The surface condition and the tolerance classes on bright steel products shall conform with Table 3. One of the classes written in brackets can be agreed at the time of enquiry and order if requested by the purchaser.

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 2.

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

This document lists the mechanical characteristics for products up to 100 mm in thickness. For dimensions greater 100 mm thickness, mechanical properties shall be agreed between manufacturer and purchaser at the time of enquiry and order.

7.2 Chemical composition

The chemical composition of the steels determined by the cast analysis shall conform with 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 also listed for information in this document, see Annex A.

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).

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If steels for case hardening or for quenching and tempering are ordered with hardenability requirements in accordance with 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.

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 conditions in Table 2, the requirements for mechanical properties specified in Tables 5 to 11 shall apply. The mechanical property values given in Tables 5 to 11 shall apply to test pieces that have been taken and prepared in accordance with Figure 1. By agreement, alternative mechanical properties may be agreed. For bright products in heat treated condition +N, +A, +FP after cold drawing and in the condition +N+SH the requirements of the relevant International Standard, i.e. ISO 630-2, ISO 683-1, ISO 683-2 or ISO 683-3, shall apply.

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 shall be performed if mentioned in the tables of mechanical properties for the condition +QT+SH/+C+QT. For cold drawn bars (+C, +C+G, +C+PL), an impact test shall not 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 Tables 5 to 11, 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 normal hardenability requirements given in ISO 683-3 shall apply. If agreed at the time of enquiry and order, alloy case-hardening steels with restricted hardenability scatterbands given in ISO 683-3 shall be supplied and these values shall apply in addition to Table 2, columns 6 and 7. By agreement, alternative hardenability may be agreed.

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 shall apply in addition to Table 2, columns 8 and 9.

NOTE In Tables 9 to 11, 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

Depending on the steel grade, machinability is possible in the condition cold drawn (+C), treated to ferrite/pearlite structure (+FP), normalized (+N) or soft annealed (+A). After machining, small changes in the shape may occur. Stress relieving' (+SR) will reduce these effects.

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.

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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, the requirement in C.3 shall be ordered.

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. See C.3 for verification only.

7.7 Non-metallic inclusions

7.7.1 Microscopic inclusions

The special steels shall have a certain degree of cleanliness, 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 according to ISO 4967 or another regional standard, e.g. EN 10247 or JIS G 0555.

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

Requirements relating to the internal soundness of the products may 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 conform with the requirements agreed at the time of enquiry and order and shall be in accordance with Table 3. If there is no agreement on the tolerance class, the bright products are delivered with the standard tolerance class given in Table 3. The tolerance class and the corresponding tolerances are given in Table 12 for rounds, squares and hexagons and in Table 13 for drawn flats. Where specified by the purchaser at the time of enquiry and order, the disposition tolerances specified in Table 12 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 14.

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Maximum deviation from 'ovality' shall be not more than half the specified tolerance range and in any case never above the upper limit of the tolerance. Any requirements concerning out of shape may be agreed at the time of enquiry and order together with the measurement method.

For the evaluation of straightness, automatic methods can be used at the discretion of the manufacturer. 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. The tolerances specified in Tables 15 and 16 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 in accordance with Table 4. 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 conforming with this document 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 must be provided, this shall cover the following information:

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

b) results of the cast analysis for all elements specified for the steel type concerned.

8.1.3 If, in accordance with the agreements made at the time of enquiry and order, an inspection certificate 3.1 or 3.2 in accordance with ISO 10474 must be provided, the specific inspections and tests

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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:

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

b) results of the cast analysis for all elements specified for the steel type 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 1.

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Table 1 — Test conditions for the verification of the requirements given in Tables 5 to 11

No.	Requirements	Amount of testing			Sampling and sample preparation	Test method to be used
		Test unit[a]	Number of [b]			
			samples per test unit	tests per sample		
1	Chemical composition	C	The cast analysis is given by the manufacturer (m); for product analysis see C.7 (o)		ISO 14284	See list in ISO/ TR 9769[c]
2	Mechanical properties				ISO 377	Tensile test[d] ISO 6892-1 Impact test ISO 148-1
2.1	As-rolled and peeled	C+D	1	1 tensile (m)		
2.2	Cold drawn	C+D	1	1 tensile (m)		
2.3	'Quenched and tempered and peeled' or 'Cold drawn and quenched and tempered'	C+D+T	1	1 tensile (m) and 3 CVN [f] (m)		
2.4	Quenched and tempered and cold drawn	C+D+T	1	1 tensile (m)		
3	Hardness[e]				ISO 6506-1	Brinell hardness test ISO 6506-1
3.1	As-rolled and peeled	C+D	1	1 (m)		
3.2	Heat-treated and peeled	C+D+T	1	1 (m)		
3.3	Heat-treated and cold drawn	C+D+T	1	1 (m)		

Verification of the requirements is only necessary if an inspection certificate is ordered.

[a] The tests shall be carried out separately for each cast as indicated by 'C', each dimension as indicated by 'D', and each heat-treatment batch as indicated by 'T'. Products with different thickness may be grouped if the differences in thickness do not affect the properties.

[b] Tests marked with an "m" (mandatory) shall be carried out as specific tests. In all cases, those marked with an "o" (optional) shall be carried out as specific tests only if agreed at ordering.

[c] For routine testing also other methods are available (e.g. spectrographic).

[d] In cases of dispute, the tensile test shall be carried out on proportional test pieces having a gauge length of $L_0 = 5{,}65 \sqrt{S_0}$, where S_0 is the original cross-section area.

[e] Unless otherwise agreed at the order, the manufacturer decides whether to use the tensile test or hardness test. In the case of dispute the tensile test shall be performed. If in the case of case hardening steels only hardness values are available, the hardness test shall be performed on the cross section at the same point as specified for the centre line of the tensile test piece.

[f] For nominal thickness ≥16 mm standard test pieces 10 mm x 10 mm shall be machined. For thicknesses <16 mm the test shall only be performed if test pieces with reduced widths and Charpy-V-notch (CVN) values are agreed at the time of enquiry and order.

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 2, the hardness requirements or mechanical properties, shall be verified with the following exception. The requirements given in Table 2, footnote c (mechanical properties of reference test pieces), shall only be verified if the supplementary requirement specified in C.2 is ordered.

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For steels being ordered with the symbol +H, +HH or +HL in the designation, unless otherwise agreed, only the hardenability requirements in accordance with ISO 683-1, ISO 683-2 and ISO 683-3 shall be verified.

8.3.2 Visual and dimensional inspection

A sufficient number of products shall be inspected to ensure the conformity 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.

If agreed at the time of enquiry and order, dimensional inspection shall be performed for bars in manufacturing or stock length for nominal diameter >100 mm, not less than 250 mm from both ends 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.

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 document, 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 on the assessment of results of sequential tests.

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 peeled/turned) and +FP+C (treated to ferrite-pearlite structure and cold drawn), the hardness tests shall be carried out in accordance with ISO 6506-1.

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9.3.2 Verification of hardenability

The verification of hardenability shall be in accordance with ISO 683-1, ISO 683-2 and ISO 683-3.

9.4 Verification of dimensions

The ovality shall be carried out by the two-point measuring method. Other methods shall be agreed at the time of enquiry and order.

9.5 Retests

Retests and criteria should 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 the identification of the cast, the steel type and the origin of the delivery is possible (see C.10).

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