
Steels for cold heading and cold extruding

Aciers pour transformation à froid et extrusion à froid

iTeh STANDARD PREVIEW
(standards.iteh.ai)

[ISO 4954:2018](https://standards.iteh.ai/catalog/standards/sist/97c32742-ebf7-4f55-ac9f-9b5c2445f296/iso-4954-2018)

<https://standards.iteh.ai/catalog/standards/sist/97c32742-ebf7-4f55-ac9f-9b5c2445f296/iso-4954-2018>



iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 4954:2018

<https://standards.iteh.ai/catalog/standards/sist/97c32742-ebf7-4f55-ac9f-9b5c2445f296/iso-4954-2018>



COPYRIGHT PROTECTED DOCUMENT

© ISO 2018

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

	Page
Foreword	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Classification and designation	3
4.1 Classification.....	3
4.2 Designation.....	3
5 Information to be supplied by the purchaser	3
5.1 Mandatory information.....	3
5.2 Options and/or supplementary or special requirements.....	4
5.3 Ordering example.....	5
6 Manufacturing process	5
6.1 General.....	5
6.2 Deoxidation.....	5
6.3 Heat-treatment condition and surface condition at delivery.....	5
6.3.1 Heat-treatment condition.....	5
6.3.2 Particular surface conditions.....	5
6.4 Traceability of the cast.....	6
6.5 Statistical evaluation.....	6
7 Requirements	6
7.1 Chemical composition, mechanical properties and hardenability.....	6
7.1.1 General.....	6
7.1.2 Chemical composition.....	6
7.1.3 Mechanical properties.....	8
7.1.4 Hardenability (only applicable to steel grades of Annexes B and C).....	8
7.2 Grain size.....	9
7.3 Carbide spheroidization (only applicable for steels of Annexes A, B and C).....	9
7.4 Non-metallic inclusions.....	9
7.4.1 Microscopic inclusions (only applicable for steels of Annexes B and C).....	9
7.4.2 Macroscopic inclusions.....	9
7.5 Internal soundness.....	9
7.6 Aptitude to cold forming.....	9
7.7 Surface quality.....	9
7.7.1 General.....	9
7.7.2 Wire rod (only applicable for steels of Annexes A, B and C).....	9
7.7.3 Bars (only applicable for steels of Annexes A, B and C).....	9
7.7.4 Wire rod and bars for stainless steels (only applicable for steels of Annex D).....	10
7.7.5 Bright products.....	10
7.7.6 Removal of surface defects.....	10
7.7.7 Non-destructive testing of the surface.....	10
7.8 Decarburization (only applicable for steels of Annexes B and C).....	10
7.9 Corrosion resistance of stainless steels.....	10
7.10 Shape, dimensions and tolerances.....	11
8 Inspection	11
8.1 Testing procedures and types of documents.....	11
8.2 Summary of specific inspection and frequency of testing.....	11
9 Preparation of samples and test pieces	12
9.1 Selection and preparation of samples for product analysis.....	12
9.2 Selection and preparation of samples and test pieces for the mechanical test.....	13
10 Test methods	14
10.1 Chemical analysis.....	14

10.2	Mechanical tests.....	14
10.3	Hardenability and core hardness tests.....	14
	10.3.1 Verification of hardenability.....	14
	10.3.2 Verification of core hardness.....	14
10.4	Aptitude to cold forming.....	14
	10.4.1 Upsetting test for non-alloy and alloy steels of Annexes A, B and C	14
	10.4.2 Upsetting test for stainless steels of Annex D	15
10.5	Non-destructive testing.....	15
10.6	Visual and dimensional test.....	15
10.7	Retests.....	15
11	Surface treatment, marking and packaging.....	15
	11.1 Surface treatment and temporary corrosion protection.....	15
	11.2 Marking.....	15
	11.3 Packaging.....	16
Annex A	(normative) Specific requirements for cold heading and cold extruding steels not intended for heat treatment after cold working.....	17
Annex B	(normative) Specific requirements for cold heading and cold extruding case-hardening steels.....	21
Annex C	(normative) Specific requirements for cold heading and cold extruding steels for quenching and tempering.....	33
Annex D	(normative) Specific requirements for cold heading and cold extruding stainless steels.....	51
Annex E	(normative) Supplementary or special requirements.....	59
Annex F	(informative) Designation of steels given in Annexes A, B, C and D and the comparable grades covered in various designation systems.....	63
Bibliography	68

ISO 4954:2018

<https://standards.iteh.ai/catalog/standards/sist/97c32742-ebf7-4f55-ac9f-9b5c2445f296/iso-4954-2018>

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 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 the following URL: 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 third edition cancels and replaces the second edition (ISO 4954:1993) which has been technically revised. The main changes compared to the previous edition are as follows:

- the names of the steel grades have been updated in accordance with ISO/TS 4949;
- for steels not intended for heat treatment, three grades have been removed and five have been added;
- for case hardening steels, eight grades have been added;
- for steels for quenching and tempering, seven grades have been removed and 27 grades have been added;
- for stainless steels, six grades have been removed and ten grades have been added;
- the list of options has been completely updated.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

ISO 4954:2018

<https://standards.iteh.ai/catalog/standards/sist/97c32742-ebf7-4f55-ac9f-9b5c2445f296/iso-4954-2018>

Steels for cold heading and cold extruding

1 Scope

This document specifies requirements for non-alloy and alloy steels that are intended for cold heading or cold extruding and are delivered as wire rods, wire or bars. It also contains specific requirements for:

- steels not intended for heat treatment, with diameters from 2 mm to 100 mm (see [Annex A](#));
- case-hardening steels with diameters from 2 mm to 100 mm (see [Annex B](#));
- steels for quenching and tempering, including boron alloyed steels (see [Table C.3](#)), with diameters from 2 mm to 100 mm (see [Annex C](#));
- stainless steels with diameters of 0,8 mm up to 50 mm for austenitic steels, up to 25 mm for ferritic steels and up to 100 mm for martensitic steels (see [Annex D](#)).

This document (except [Annex A](#)) is applicable to the properties of cold-headed or cold-extruded parts which have been subjected to a subsequent heat treatment. As the properties of the parts in the cold-headed or cold-extruded, and subsequently not-heat-treated condition, are largely dependent on the applied cold-heading or cold-extruding conditions, these are, if necessary, subject to agreement between the purchaser and the manufacturer of the parts.

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

2 Normative references

[ISO 4954:2018](#)

<https://standards.iteh.ai/catalog/standards/sist/97c32742-ebf7-4f55-ac9f-79b11641791c/iso-4954-2018>

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 404, *Steel and steel products — General technical delivery requirements*

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

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

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 683-18:2014, *Heat-treatable steels, alloy steels and free-cutting steels — Part 18: Bright steel products*

ISO 1035-1, *Hot-rolled steel bars — Part 1: Dimensions of round bars*

ISO 1035-2, *Hot-rolled steel bars — Part 2: Dimensions of square bars*

ISO 1035-3, *Hot-rolled steel bars — Part 3: Dimensions of flat bars*

ISO 1035-4, *Hot-rolled steel bars — Part 4: Tolerances*

ISO 4954:2018(E)

ISO 3651-2, *Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid*

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 4967:2013, *Steel — Determination of content of non-metallic inclusions — Micrographic method using standard diagrams*

ISO 6508-1, *Metallic materials — Rockwell 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 9934-1, *Non-destructive testing — Magnetic particle testing — Part 1: General principles*

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 15549, *Non-destructive testing — Eddy current testing — Part 1: General principles*

ISO 16124, *Steel wire rod — Dimensions and tolerances*

ISO 16143-2, *Stainless steels for general purposes — Part 2: Corrosion-resistant semi-finished products, bars, rods and sections*

ISO 22034-2, *Steel wire and wire products — Part 2: Tolerances on wire dimensions*

JIS G 0555:2015, *Microscopic testing method for the non-metallic inclusions in steel*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 377, ISO 683-1, ISO 683-2, ISO 683-3, ISO 683-18, ISO 4885, ISO 4948-1, ISO 4948-2, ISO 6929, ISO 14284, ISO 16143-2 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 <http://www.electropedia.org/>

3.1

bright steel product

drawn or peeled/turned bar with smoother surface quality and better dimensional accuracy in comparison with a hot-rolled bar

3.2

drawn product

product of various cross-sectional shapes obtained, after descaling, by cold drawing of hot-rolled bars or wire rod, on a drawing bench (cold deformation without removing material)

Note 1 to entry: This operation gives the product special features with respect to shape, dimensional accuracy and surface finish. Products in lengths are delivered straightened, products of small cross-section may also be supplied in coils.

3.3

peeled/turned product

steel bar of circular cross-section having the same features of *drawn products* (3.2) concerning shape, dimensional accuracy and bright surface finish but without work hardening

Note 1 to entry: They are produced by peeling on a peeling machine usually followed by straightening and by polishing. The removal of metal by peeling is carried out in such a way that the bright product is generally free from surface defects and decarburization coming from the hot-rolling process.

4 Classification and designation

4.1 Classification

The classification of the relevant steel grades shall be in accordance with ISO 4948-1 and ISO 4948-2.

All steel grades mentioned in this document are special steels in accordance with ISO 4948-2.

The steels not intended for heat treatment after cold forming (see [Annex A](#)) are non-alloy steels.

The case hardening steel grades (see [Annex B](#)) are alloy steels, except steel grades C10E2C to C20E2C.

The steel grades for quenching and tempering (see [Annex C](#)) are alloy steel grades, except steel grades C35EC to C45RC.

The steel stainless steel grades (see [Annex D](#)) are classified according to their microstructures.

4.2 Designation

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

[Annex F](#) provides a list of steels given in [Annexes A, B, C](#) and [D](#) and the comparable grades covered in various designation systems.

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 (mass, length);
- b) the product form (round bar, wire rod, wire);
- c) the nominal diameter and the tolerances on dimensions and shape of the product with reference to the relevant International Standard;
- d) for bars the length and for wire rod and wire the dimensions, i.e. inner diameter and mass of the coils;
- e) reference to this document, i.e. ISO 4954;

- f) the designation of the steel grade given in [Tables A.2, B.2, C.2, C.3](#) and [D.2](#);
- g) if applicable, the symbol for the required heat-treatment condition, see [Tables A.3, B.3](#) to [B.7, C.4](#) to [C.10](#) and [D.3](#) to [D.6](#);
- h) 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 and/or supplementary or special requirements

A number of options are specified in this document and listed below. If the purchaser does not indicate a wish to implement any of these options, the products will be supplied in accordance with the basic specifications of this document (see [5.1](#)).

- a) Any requirement for the hardenability (+H, +HH, +HL) of case hardening steels of [Annex B](#) and of steels for quenching and tempering of [Annex C](#) and for the core hardening (+CH) of steels for quenching and tempering of [Annex C](#), see [7.1.4](#).
- b) Verification of hardenability and, if agreed, information about the calculation of the hardenability for the case hardening steels of [Annex B](#) and for the steels for quenching and tempering of [Annex C](#), see [10.3.1](#).
- c) If another surface condition than hot-rolled or a special surface quality is required, for the surface condition, see [Table 1](#), and for the surface quality of E for bars and D for wire rod, see [7.7.2](#) and [7.7.3](#).
- d) Any requirement relating to the removal of surface defects, see [7.7.6](#).
- e) Any requirement for the verification of the surface quality, see [7.7.5](#).
- f) Any requirement for a product analysis, see [7.1.2.2](#).
- g) Any requirement for the verification of the fine grain structure, see [E.2](#), of case hardening steels of [Annex B](#) and of steels for quenching and tempering of [Annex C](#).
- h) Carbide spheroidization, see [7.3](#), and any requirement for the verification of the carbide spheroidization, see [E.3](#).
- i) Any requirement for the verification of the non-metallic inclusions of case hardening steels of [Annex B](#) and of steels for quenching and tempering of [Annex C](#), see [7.4](#) and [E.4](#).
- j) Internal soundness and any requirements for non-destructive testing, see [7.5](#) and [10.5](#).
- k) Verification of aptitude to cold forming, see [7.6](#) and [10.4](#).
- l) Maximum depth of surface discontinuities for stainless steels, see [7.7.4](#) and [E.5](#).
- m) Any requirement concerning non-destructive testing of the surface, see [7.7.7](#) and [10.5](#).
- n) Depth of decarburization, see [7.8](#), and any requirements for testing the depth of decarburization, see [E.6](#).
- o) Corrosion resistance of stainless steel products and any requirements for resistance to intergranular corrosion, see [E.7](#).
- p) Any requirement concerning surface treatment and temporary corrosion protection, see [11.1](#).
- q) Any special requirements concerning special or additional marking, see [11.2](#).
- r) Any special requirements concerning packaging, see [11.3](#).
- s) Statistical evaluation, see [6.5](#).

5.3 Ordering example

EXAMPLE 50 t round bars with a nominal diameter of 40 mm and a nominal length of 6 000 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 4954 42CrMo4 in the heat-treatment condition +AC+PE (see [Table C.5](#)), with hardenability requirement +H (see [Table C.7](#)) and product analysis with an inspection certificate 3.1 in accordance with ISO 10474.

50 t round bars ISO 1035-4 - 40,0S × 6 000L2

ISO 4954 - 42CrMo4+AC+PE+H - product analysis

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.

6.2 Deoxidation

All steels shall be deoxidized. The steels not intended for heat treatment (see [Annex A](#)) are aluminium or silicon killed. By agreement, aluminium may be replaced by another suitable element having a similar effect.

iTeh STANDARD PREVIEW

6.3 Heat-treatment condition and surface condition at delivery

6.3.1 Heat-treatment condition ISO 4954:2018

<https://standards.iteh.ai/catalog/standards/sist/97c32742-ebf7-4f55-ac9f-363241a21943/iso-4954-2018>

Treatment and heat-treatment condition shall conform to one of the conditions indicated in [Tables A.1](#), [B.1](#), [C.1](#) and [D.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. Any surface treatment that can facilitate subsequent cold heading and cold extrusion or partially delay any formation of rust shall, if required, be agreed at the time of enquiry and order, see [11.1](#).

6.3.2 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 1](#).

Table 1 — Surface condition at delivery

Surface condition at delivery		Symbol	Bar	Wire rod	Wire
Particular surface conditions supplied by agreement	as-rolled	none or +AR	x	x	—
	cold drawn	+C	x	—	x
	skin passed	+LC	x	—	x
	peeled	+PE	x	x	x

6.4 Traceability of the cast

Each product shall be traceable to the cast, see [11.2](#).

6.5 Statistical evaluation

Suppliers are responsible, using the means they think fit, for inspecting their product in accordance with various quality criteria specified. In view of the practical difficulties in inspecting a coil of wire rod along its entire length, it cannot be proved that no value greater than the specified limits is to be found in the coil as a whole. Statistical evaluation of performances applicable to all coils may be agreed between the purchaser and the manufacturer at the time of ordering.

7 Requirements

7.1 Chemical composition, mechanical properties and hardenability

7.1.1 General

Wire rod, bars and wire shall be supplied in one of the delivery conditions as indicated in [Tables A.1](#), [B.1](#), [C.1](#) and [D.1](#) as agreed at the time of enquiry and order. These tables show the combinations of usual heat-treatment conditions at delivery, product forms and applicable requirements.

7.1.2 Chemical composition

7.1.2.1 The chemical composition determined by cast analysis shall conform to the values in [Tables A.2](#), [B.2](#), [C.2](#), [C.3](#) and [D.2](#).

In cases where steels for case hardening or for quenching and tempering are ordered with hardenability requirements in accordance with [Tables B.6](#), [B.7](#), [C.7](#), [C.8](#) and [C.9](#), a deviation of the cast analysis with respect to the values indicated in [Tables B.2](#), [C.2](#) and [C.3](#) is admissible, taking into account the prescriptions given in footnote b) of those tables. In any case, however, the deviations in the product analysis in relation to the specified limits of cast analysis shall not exceed the values indicated in [Table 2](#).

7.1.2.2 Permissible deviations between the limiting values for cast analysis and the values for product analysis are given in [Tables 2](#) and [3](#). The product analysis shall be carried out when specified at the time of the enquiry and order.

Table 2 — Permissible deviations between product analysis and the limiting values of the cast analysis specified in [Tables A.2](#), [B.2](#), [C.2](#) and [C.3](#)

Elements	Limiting values of the cast (heat) analysis % mass fraction	Permissible deviation for the product analysis % mass fraction ^a
For non-alloy and alloy steel grades of Annexes A , B and C		
C	≤ 0,50	±0,02
Si	≤ 1,00	±0,03
Mn	≤ 1,00	±0,04
	> 1,00 ≤ 1,45	±0,06
P	≤ 0,025	+0,005

^a ± means that in one heat the deviation of the product analysis for a given element may occur over the upper value or under the lower value of the specified range of the cast analysis, but not both at the same time.

^b For steels with a specified sulfur range (0,020 % to 0,035 or 0,040 %) according to cast analysis, the permissible deviation is ±0,005 %.

Table 2 (continued)

Elements	Limiting values of the cast (heat) analysis % mass fraction	Permissible deviation for the product analysis % mass fraction ^a
S	≤ 0,040	+0,005 ^b
Cr	≤ 1,70	±0,05
Ni	≤ 1,00	±0,03
	> 1,00 ≤ 2,00	±0,05
Mo	≤ 0,30	±0,03
	> 0,30 ≤ 0,50	±0,04
Al	≤ 0,060	±0,005
B	≤ 0,005 0	±0,000 3
Cu	≤ 0,25	+0,03

^a ± means that in one heat the deviation of the product analysis for a given element may occur over the upper value or under the lower value of the specified range of the cast analysis, but not both at the same time.

^b For steels with a specified sulfur range (0,020 % to 0,035 or 0,040 %) according to cast analysis, the permissible deviation is ±0,005 %.

Table 3 — Permissible deviations between product analysis and the limiting values of the cast analysis specified in Table D.2

Elements	Limiting values of the cast (heat) analysis % mass fraction	Permissible deviation for the product analysis % mass fraction ^a
For stainless steel grades of Annex D		
C	≤ 0,030	+0,005
	> 0,030 ≤ 0,15	±0,01
Si	≤ 1,00	+0,05
	> 1,00 ≤ 2,00	±0,10
Mn	≤ 1,00	+0,03
	> 1,00 ≤ 2,00	±0,04
P	≤ 0,045	+0,005
S	≤ 0,015	+0,003
	> 0,015 ≤ 0,030	±0,005
Cr	≥ 11,5 < 15,0	±0,15
	≥ 15,0 ≤ 20,0	±0,20
	> 20,0 ≤ 23,0	±0,25
Ni	≤ 1,00	+0,03
	> 1,00 ≤ 5,0	±0,07
	> 5,0 ≤ 10,0	±0,10
	> 10,0 ≤ 20,0	±0,15
Mo	> 20,0 ≤ 27,0	±0,20
	< 1,75	±0,05
N	≥ 1,75 ≤ 3,5	±0,10
	≤ 0,22	±0,02

^a ± means that in one heat the deviation of the product analysis for a given element may occur over the upper value or under the lower value of the specified range of the cast analysis, but not both at the same time.

Table 3 (continued)

Elements	Limiting values of the cast (heat) analysis % mass fraction	Permissible deviation for the product analysis % mass fraction ^a
Al	≤ 0,35	+0,10
B	> 0,001 ≤ 0,010	±0,000 5
Cu	≤ 1,00	+0,04
	> 1,00 ≤ 4,0	±0,10
Ti	≤ 1,00	±0,05
	> 1,00 ≤ 2,35	±0,07
V	≤ 0,50	±0,03

^a ± means that in one heat the deviation of the product analysis for a given element may occur over the upper value or under the lower value of the specified range of the cast analysis, but not both at the same time.

7.1.3 Mechanical properties

The mechanical properties of the products, to be determined by the tensile test (and, as an option, either by end quench test hardenability requirements or by core hardening requirements for steels of [Annexes B](#) and [C](#)) and by consideration of the delivery conditions of [Tables A.1, B.1, C.1](#) and [D.1](#) and of the surface condition of [Table 1](#), shall conform to [Tables A.3, B.3, B.4, B.5, C.4, C.5, C.6, D.3, D.4, D.5](#) and [D.6](#).

7.1.4 Hardenability (only applicable to steel grades of [Annexes B](#) and [C](#))

7.1.4.1 Where the steel is not ordered with hardenability or core hardening requirements, the requirements for mechanical properties apply as given in [Tables B.3, B.4, B.5, C.4, C.5](#) and [C.6](#). In this case, the hardenability values given in [Tables B.6, B.7, C.7, C.8](#) and [C.9](#) and the core hardness values in [Table C.10](#) are for guidance purposes only.

7.1.4.2 In the case of products ordered with standard requirements regarding hardenability, that is, when the steel names or numbers are supplemented by the symbol “+H”, the hardness values obtained in the end quench test (Jominy test) shall conform to the values given in [Tables B.6, C.7](#) and [C.8](#).

In the case of products ordered with restricted requirements regarding the scatter bands of the hardness values obtained by the Jominy test, that is, when the steel name or number is supplemented by the symbols “+HH” or “+HL”, the above hardness values shall conform to the values given in [Tables B.7](#) and [C.9](#).

NOTE 1 The symbol “+HH” denotes that the upper limit of the scatter band coincides with the upper limit for the corresponding steel “+H”.

NOTE 2 The symbol “+HL” denotes that the lower limit of the scatter band coincides with the lower limit for the corresponding steel “+H”.

NOTE 3 For hardenability by calculation and for verification of hardenability, see [10.3](#).

The austenizing temperatures for the Jominy test are given in [Tables B.6, B.7, C.7, C.8](#) and [C.9](#).

7.1.4.3 In the case of steels for quenching and tempering (see [Annex C](#)) ordered with core hardening requirements, that is, when the steel names or number are supplemented by the symbol “+CH”, the minimum core hardness shall conform to the values given in [Table C.10](#).

At least 90 % of the structure shall be martensite.

7.2 Grain size

Steels of [Annexes B](#) and [C](#) (except the non-alloy grades C35EC to C45RC) shall have a fine grain structure with an austenite grain size number of 5 or finer. For verification, see [E.2](#).

For steels of [Annex A](#), the non-alloy grades C35EC to C45RC of [Annex C](#) and the steels of [Annex D](#), unless otherwise agreed, the austenitic grain size is left to the manufacturer's discretion.

7.3 Carbide spheroidization (only applicable for steels of [Annexes A, B and C](#))

If carbide spheroidization is requested, reference shall be made to [E.3](#).

7.4 Non-metallic inclusions

7.4.1 Microscopic inclusions (only applicable for steels of [Annexes B and C](#))

The special steels shall have a certain degree of cleanness. However, verification of the non-metallic inclusion content requires a special agreement. For such an agreement, see [E.4](#).

7.4.2 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.

7.5 Internal soundness

Wire rod, bars and wire shall be free from internal defects, which may cause an adverse effect on products during cold heading or cold extrusion or during heat treatment.

Where appropriate, ~~non-destructive testing relating to the internal soundness~~ ^{ISO 4954:2018} shall be agreed at the time of enquiry and order; see [10.5](#) ^{ISO-4954-2018}.

7.6 Aptitude to cold forming

A test for verification of the aptitude of products to cold forming may be carried out if agreed at the time of enquiry and order with reference to [10.4](#)

7.7 Surface quality

7.7.1 General

All products shall have a smooth surface finish appropriate to the manufacturing process applied. For hot-rolled products, minor surface imperfections, which may occur also under normal manufacturing conditions, such as prints originating from rolled-in scale, are shall not be regarded as defects. 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.

7.7.2 Wire rod (only applicable for steels of [Annexes A, B and C](#))

Wire rod shall meet surface quality requirements in accordance with ISO 9443 quality class D. For certain higher applications, quality class E in accordance with ISO 9443 is appropriate and may be agreed at the time of enquiry and order.

7.7.3 Bars (only applicable for steels of [Annexes A, B and C](#))

Bars shall meet surface quality requirements in accordance with ISO 9443 quality class D. Conformity to surface quality in accordance with ISO 9443 quality class E may be agreed at the time of enquiry and