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**Steel flat products for pressure  
purposes — Technical delivery  
conditions —**

Part 2:  
**Non-alloy and alloy steels with  
specified elevated temperature  
properties**

*Produits plats en acier pour service sous pression — Conditions  
techniques de livraison —*

*Partie 2: Aciers non alliés et aciers alliés avec caractéristiques  
spécifiées à température élevée*

ISO 9328-2:2018

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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](http://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](http://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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 10, *Steel for pressure purposes*.

This fourth edition cancels and replaces the third edition (ISO 9328-2:2011), which has been technically revised. The following changes have been made:

- the term “product thickness” has been replaced with “nominal thickness”;
- normalizing rolling is also considered for steel grade 16Mo3 (see [Annex A](#));
- the technical data in [Annex A](#) have been aligned with EN 10028-2;
- in [Table B.1](#), “B ≤ 0,001 0” has been added and the specifications of “P” and “S” have been changed.

A list of all the parts in the ISO 9328 series can be found on the ISO website.

# Steel flat products for pressure purposes — Technical delivery conditions —

## Part 2:

# Non-alloy and alloy steels with specified elevated temperature properties

## 1 Scope

This document specifies the technical delivery conditions for plates and strip for pressure equipment made of non-alloy and alloy steels as specified in [Tables A.1](#) and [B.1](#). The requirements and definitions of ISO 9328-1 also apply to this document.

## 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 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 9328-1:2018, *Steel flat products for pressure purposes — Technical delivery conditions — Part 1: General requirements*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 9328-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

## 4 Classification and designation

### 4.1 Classification

In accordance with ISO 4948-1 and ISO 4948-2, the steel grades P235GH, P265GH, P295GH and P355GH (see [Annex A](#)) and PT410GH, PT450GH and PT480GH (see [Annex B](#)) are non-alloy-quality steels. All other grades are alloyed special steels.

## 4.2 Designation

Shall be in accordance with ISO 9328-1.

NOTE 1 Non-alloy grades in [Annex A](#) are classified in accordance with their yield strength, non-alloy grades in [Annex B](#) are classified in accordance with their tensile strength.

NOTE 2 Information on the designation of comparable steel grades in national or regional standards is given in [Annex C](#).

## 5 Information to be supplied by the purchaser

### 5.1 Mandatory information

Shall be in accordance with ISO 9328-1 and [6.2.3](#).

### 5.2 Options

A number of options are specified in this document. These are listed below under a) to t). Additionally, the relevant options of ISO 9328-1 apply. If the purchaser does not indicate a wish to implement any of these options at the time of enquiry and order, the products shall be supplied in accordance with the basic specification (shall be in accordance with ISO 9328-1):

- a) tests in the simulated normalized condition (see [6.2.2](#));
- b) products delivered untreated (see [6.2.4](#) and [6.2.5](#));
- c) maximum carbon-equivalent value for P235GH, P265GH, P295GH and P355GH (see [6.3.3](#));
- d) specification of an impact energy value of 40 J (see [Table A.2](#), footnote h);
- e) test on simulated heat-treated samples (see [6.7.2](#));
- f) hydrogen-induced cracking (HIC) test in accordance with [Annex G](#) (see [6.10](#));
- g) step cooling test in accordance with [Annex H](#) (see [6.11](#));
- h) mid-thickness test pieces for the impact test and/or tensile test (see [Clause 8](#));
- i) lower copper content and maximum tin content (see [Table A.1](#), footnote b);
- j) minimum chromium content of 0,80 % (see [Table A.1](#), footnote f);
- k) maximum carbon content of 0,17 % for nominal thicknesses greater than 150 mm (see [Table A.1](#), footnote g);
- l) maximum contents of Al ( $\leq 0,020$  %), Ti ( $\leq 0,01$  %) and Zr ( $\leq 0,01$  %) (see [Table A.1](#), footnote i);
- m) mechanical properties for nominal thicknesses > 250 mm (see [Table A.2](#), footnote a);
- n) specification of the delivery condition +QT where the usual delivery condition is +NT (see [Table A.2](#), footnote c and [Table A.3](#), footnote c);
- o) additional impact energy values (see [Table A.2](#), footnote i);
- p) 0,2 % proof strength ( $R_{p0,2}$ ) values at elevated temperature for increased nominal thicknesses (see [Table A.3](#), footnote b);
- q) increased carbon content for grades PT410GH, PT450GH and PT480GH (see [Table B.1](#), footnote c);
- r) Al additions not permitted (see [Table B.1](#), footnote d);

- s) specification of the delivery condition +NT for the grade 14CrMo9-10 and of the delivery condition +QT for the grades 14CrMoV9-10 and 13CrMoV12-10 (see [Table B.2](#), footnote i);
- t) requirement for impact tests and values (see [Table B.2](#), footnote i).

### 5.3 Example for ordering

An order of 10 plates with nominal dimensions thickness = 50 mm, width = 2 000 mm, length = 10 000 mm, made of a steel grade with the name 16Mo3 as specified in this document, with inspection certificate 3.1 as specified in ISO 10474, is designated as follows:

**10 plates – 50 × 2 000 × 10 000 – ISO 9328-2 16Mo3 – Inspection certificate 3.1**

## 6 Requirements

### 6.1 Steelmaking process

Shall be in accordance with ISO 9328-1.

### 6.2 Delivery condition

**6.2.1** Unless otherwise agreed at the time of enquiry and order, the products covered by this document shall be supplied in the usual conditions given in [Tables A.2](#) and [B.2](#).

**6.2.2** Normalizing may, at the discretion of the manufacturer, be replaced with normalizing rolling for the steel grades P235GH, P265GH, P295GH, P355GH and 16Mo3 (see [Annex A](#)). In this case, additional tests in the simulated normalized condition with an agreed frequency of testing may be agreed upon at the time of enquiry and order to verify that the obtained properties also comply with the standard requirements (see [5.2](#), Option 1).

**6.2.3** For products made of steel grades PT410GH, PT450GH, PT480GH, 19MnMo4-5, 19MnMo5-5 and 19MnMoNi5-5 (see [Table B.2](#)), the requested delivery condition normalized (+N) or untreated (+AR) (but see [6.2.5](#)) or, where applicable, quenched and tempered (+QT) shall be specified at the time of enquiry and order.

**6.2.4** If so agreed at the time of enquiry and order, products made of steel grades P235GH, P265GH, P295GH, P355GH and 16Mo3 (see [Table A.2](#)) may also be delivered in the untreated condition (but see [6.2.5](#)). Products made of one of the other alloy grades may be supplied in the tempered or normalized condition or in the untreated condition, if so agreed.

The plates delivered in untreated conditions shall be appropriately marked (+AR) to denote that heat treatment has not been performed. Steel grades containing more than 2 % Cr (inclusive) shall be supplied in a stress relieved condition as a minimum.

NOTE [Annex D](#) contains heat treatment information for the purchaser.

**6.2.5** For products delivered untreated in accordance with [6.2.3](#) and [6.2.4](#), testing shall be carried out by the processor on test pieces in usual delivery condition as indicated in [Tables A.2](#) and [B.2](#).

NOTE Tests in a simulated heat-treated condition are made to verify the suitability of the delivered product in the delivery condition +N, or +NT or +QT, as appropriate. However, they do not discharge the processor from the obligation of providing proof of the specified properties in the finished product when adequately heat treated.

### 6.3 Chemical composition

**6.3.1** The requirements of [Tables A.1](#) and [B.1](#) shall apply for the chemical composition according to the cast (heat) analysis.

**6.3.2** The product analysis shall not deviate from the values for the cast (heat) analysis specified in [Tables A.1](#) and [B.1](#) by more than the values given in [Table 1](#).

**6.3.3** A maximum value for the carbon equivalent may be agreed upon at the time of enquiry and order for steel grades P235GH, P265GH, P295GH and P355GH (see [Annex A](#)) and PT410GH, PT450GH and PT480GH (see [Annex B](#)). In this case, [Formula \(1\)](#) shall apply for calculation of the carbon-equivalent value (CEV):

$$CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \quad (1)$$

**Table 1 — Permissible product analysis tolerances on the limiting values given in [Tables A.1](#) and [B.1](#) for the cast (heat) analysis**

Element	Specified value in the cast (heat) analysis according to <a href="#">Tables A.1</a> and <a href="#">B.1</a>	Permissible deviation of the product analysis <sup>a</sup>
	% by mass	% by mass
Cb	≤ 0,31	±0,02
Si	≤ 0,35	±0,05
	> 0,35 to ≤ 1,00	±0,06
Mn	≤ 1,00	±0,05
	> 1,00 to ≤ 1,70	±0,10
pb	≤ 0,015	+0,003
	> 0,015 to ≤ 0,030	+0,005
Sb	≤ 0,010	+0,003
Al	≥ 0,010	±0,005
B	≤ 0,003	+0,000 5
Ca	≤ 0,015	+0,003
N	≤ 0,020	+0,002
	> 0,020 to ≤ 0,070	±0,005
Cr	≤ 2,00	±0,05
	> 2,00 to ≤ 10,00	±0,10
Cu	≤ 0,30	±0,05
	> 0,30 to ≤ 0,80	±0,10
Mo	≤ 0,35	±0,03
	> 0,35 to ≤ 1,10	+0,04
Nb	≤ 0,10	±0,01
Ni	≤ 0,30	+0,05
	> 0,30 to ≤ 1,30	±0,10

<sup>a</sup> If several product analyses are carried out on one cast, and the contents of an individual element determined lie outside the permissible range of the chemical composition specified for the cast analysis, then it is only allowed to exceed the permissible maximum value or fall short of the permissible minimum value, but not both for one cast.

<sup>b</sup> In the case of steel grades specified in [Annex B](#), the maximum values listed in [Table B.1](#) also apply for the product analysis, except that Boron shall be 0,001 5 % for PT410GH, PT450GH, PT480GH, 19MnMo4-5, 19MnMo5-5, 19MnMo6-5, 19MnMoNi5-5, 19MnMoNi6-5 and 0,003 % for 14CrMoV9-10.



Table 1 (continued)

Element	Specified value in the cast (heat analysis according to <a href="#">Tables A.1</a> and <a href="#">B.1</a> ) % by mass	Permissible deviation of the product analysis <sup>a</sup> % by mass
Cr+Cu+Mo+Ni	≤ 1,00	+0,05
Ti	≤ 0,035	±0,01
V	≤ 0,05	±0,01
	> 0,05 to ≤ 0,30	±0,03

<sup>a</sup> If several product analyses are carried out on one cast, and the contents of an individual element determined lie outside the permissible range of the chemical composition specified for the cast analysis, then it is only allowed to exceed the permissible maximum value or fall short of the permissible minimum value, but not both for one cast.

<sup>b</sup> In the case of steel grades specified in [Annex B](#), the maximum values listed in [Table B.1](#) also apply for the product analysis, except that Boron shall be 0,001 5 % for PT410GH, PT450GH, PT480GH, 19MnMo4-5, 19MnMo5-5, 19MnMo6-5, 19MnMoNi5-5, 19MnMoNi6-5 and 0,003 % for 14CrMoV9-10.

## 6.4 Mechanical properties

**6.4.1** The values given in [Tables A.2](#), [A.3](#) and [B.2](#) (see also ISO 9328-1) shall apply.

**6.4.2** [Annex F](#) gives, for the grades in [Annex A](#), mean values as preliminary data for the purchaser on the strength for 1 % (plastic) creep strain and creep rupture.

## 6.5 Surface condition

Shall be in accordance with ISO 9328-1.

## 6.6 Internal soundness

Shall be in accordance with ISO 9328-1.

## 6.7 Weldability

**6.7.1** The steel grades specified in this document shall be suitable for welding processes in current use (see also the Note to [6.7.2](#)).

**6.7.2** Information on welding can be found in appropriate documents, e.g. EN 1011-1 and EN 1011-2 or IIS/IIW 382-71.

Excessive post-weld heat treatment (PWHT) conditions can decrease the mechanical properties. When in stress relieving, the intended time-temperature parameter shown by [Formula \(2\)](#):

$$P = T_s (20 + \lg t) \times 10^{-3} \quad (2)$$

where

$T_s$  is the stress relieving temperature, in kelvins;

$t$  is the holding time, in hours.

exceeds the critical ( $P_{crit.}$ ) values in [Annex E](#), or where regarded as necessary in the case of [Annex B](#) steel grades, the purchaser should, in his enquiry and order, inform the manufacturer accordingly.

Where appropriate, tests on simulated heat-treated samples may be agreed at the time of enquiry and order to check whether, after such a treatment, the properties specified in this document can still be regarded as valid (see [5.2](#), Option 5).

## 6.8 Dimensions and tolerances on dimensions

Shall be in accordance with ISO 9328-1.

## 6.9 Calculation of mass

Shall be in accordance with ISO 9328-1.

## 6.10 Resistance to hydrogen-induced cracking

Since carbon and low-alloy steels may be susceptible to cracking when exposed to corrosive H<sub>2</sub>S-containing environments, usually referred to as “sour service”, a test to evaluate the resistance to hydrogen-induced cracking in accordance with [Annex G](#) or another test method may be agreed at the time of enquiry and order.

## 6.11 Embrittlement of CrMo steels

CrMo steels may tend to become brittle in service at temperatures between approximately 400 °C and 500 °C. This possible tendency for embrittlement can be simulated in the laboratory with the so-called step cooling test. In this test, a specimen is exposed to a temperature-time cycle as given in [Figure H.1](#). The shift of a transition curve before and after the step cooling test is a measure for the embrittlement.

A step cooling test in accordance with [Annex H](#) may be agreed upon at the time of enquiry and order.

NOTE The step cooling test is primarily applicable to the weld metal and the heat-affected zone.

## 7 Inspection

### 7.1 Types of inspection and inspection documents

Shall be in accordance with ISO 9328-1.

### 7.2 Tests to be carried out

Shall be in accordance with ISO 9328-1 and [6.10](#) and [6.11](#).

### 7.3 Retests, sorting and reprocessing

Shall be in accordance with ISO 9328-1.

## 8 Sampling

Shall be in accordance with ISO 9328-1.

For an impact test (and/or the tensile test), that deviates from ISO 9328-1:2018, Table 3, footnote e, test pieces taken from the mid-thickness may be agreed upon at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed upon.

## 9 Test methods

9.1 Shall be in accordance with ISO 9328-1, and [Annexes D](#) and [E](#).

**9.2** For the steel grades specified in [Annex B](#), the impact test shall only be carried out if so agreed at the time of enquiry and order. Requirements and test conditions shall then also be agreed (see [Table B.2](#), footnote 1).

## **10 Marking**

Shall be in accordance with ISO 9328-1.

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**Annex A**  
(normative)

**Chemical composition and mechanical properties of products  
based on European standards**

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