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

Part 2:

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

iTeh STANDARD PREVIEW

*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*

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 9328-2 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 10, *Steel for pressure purposes*.

This third edition cancels and replaces the second edition (ISO 9328-2:2004), which has been technically revised.

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ISO 9328 consists of the following parts, under the general title *Steel flat products for pressure purposes — Technical delivery conditions*:

- *Part 1: General requirements*
- *Part 2: Non-alloy and alloy steels with specified elevated temperature properties*
- *Part 3: Weldable fine grain steels, normalized*
- *Part 4: Nickel-alloy steels with specified low temperature properties*
- *Part 5: Weldable fine grain steels, thermomechanically rolled*
- *Part 6: Weldable fine grain steels, quenched and tempered*
- *Part 7: Stainless steels*

The clauses marked by a point (•) contain information relating to agreements that shall be made at the time of enquiry and order. The clauses marked by two points (••) contain information relating to agreements that may be made at the time of enquiry and order.

Steel flat products for pressure purposes — Technical delivery conditions —

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

1 Scope

This part of ISO 9328 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 part of ISO 9328.

2 Normative references

The following normative documents are indispensable for the application 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 4948-1:1982, *Steels — Classification — Part 1: Classification of steels into unalloyed and alloy steels based on chemical composition*

ISO 4948-2:1981, *Steels — Classification — Part 2: Classification of unalloyed and alloy steels according to main quality classes and main property or application characteristics*

ISO 9328-1:2011, *Steel flat products for pressure purposes — Technical delivery conditions — Part 1: General requirements*

ISO 10474:1991, *Steel and steel products — Inspection documents*

EN 10229:1998, *Evaluation of resistance of steel products to hydrogen induced cracking (HIC)*

EN 10314, *Method for the derivation of minimum values of proof strength of steel at elevated temperatures*

3 Terms and definitions

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

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

See 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

See ISO 9328-1 and 6.2.3.

5.2 Options

A number of options are specified in this part of ISO 9328. 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 (see 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 product 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 product 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 product 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 j);
- t) requirement for impact tests and values (see Table B.2, footnote l);

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 ISO 9328-2, to be delivered normalized, with inspection document 3.1.B as specified in ISO 10474:1991 is designated as follows:

10 plates – 50 × 2 000 × 10 000 – ISO 9328-2 16Mo3 – Inspection document 3.1.B

6 Requirements

6.1 Steelmaking process

See 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 part of ISO 9328 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 and P355GH (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.

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.

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 on test pieces in the 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, the following formula shall apply for calculation of the carbon-equivalent value (CEV):

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

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 Tables A.1 and B.1 % by mass | Permissible deviation of the product analysis ^a % by mass |
|----------------|--|---|
| C ^b | ≤ 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 |
| P ^b | ≤ 0,015 | +0,003 |
| | > 0,015 to ≤ 0,030 | +0,005 |
| S ^b | ≤ 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 |
| 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 |

^a 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.

^b In the case of steel grades specified in Annex B, the maximum values listed in Table B.1 also apply for the product analysis.

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

See ISO 9328-1.

6.6 Internal soundness

See ISO 9328-1.

6.7 Weldability

6.7.1 The steel grades specified in this part of ISO 9328 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.

NOTE Excessive post-weld heat treatment (PWHT) conditions can decrease the mechanical properties. When in stress relieving, the intended time-temperature parameter

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

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 part of ISO 9328 can still be regarded as valid.

6.8 Dimensions and tolerances on dimensions

See ISO 9328-1.

6.9 Calculation of mass

See ISO 9328-1.

6.10 Resistance to hydrogen-induced cracking

Carbon and low-alloy steels may be susceptible to cracking when exposed to corrosive H₂S-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

See ISO 9328-1.

7.2 Tests to be carried out

See ISO 9328-1 and 6.10 and 6.11.

7.3 Retests

See ISO 9328-1.

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8 Sampling

See ISO 9328-1.

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- For the impact test and/or the tensile test, deviating from ISO 9328-1:2011, Table 3, footnote e, by preparing 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 See 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 I).

10 Marking

See ISO 9328-1.

Annex A
(normative)

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

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Table A.1 — Chemical composition [cast (heat) analysis]

| Steel grade | % by mass ^a | | | | | | | | | | | | | | |
|-----------------|------------------------------|-----------------|------------------------------|--------|--------|----------------------|----------------------|------------------------------|-----------------|-----------------|-------------------|-----------------|---------|--------|-------------------------|
| | C | Si | Mn | P max. | S max. | Al _{total} | N | Cr | Cu ^b | Mo | Nb | Ni | Ti max. | V | Others |
| P235GH | ≤ 0,16 | ≤ 0,35 | 0,60 ^c to 1,20 | 0,025 | 0,010 | ≥ 0,020 ^d | ≤ 0,012 ^d | ≤ 0,30 | ≤ 0,30 | ≤ 0,08 | ≤ 0,020 | ≤ 0,30 | 0,03 | ≤ 0,02 | — |
| P265GH | ≤ 0,20 | ≤ 0,40 | 0,80 to 1,40 | 0,025 | 0,010 | ≥ 0,020 ^d | ≤ 0,012 ^d | ≤ 0,30 | ≤ 0,30 | ≤ 0,08 | ≤ 0,020 | ≤ 0,30 | 0,03 | ≤ 0,02 | — |
| P295GH | 0,08 to 0,20 | ≤ 0,40 | 0,90 to 1,50 | 0,025 | 0,010 | ≥ 0,020 ^d | ≤ 0,012 ^d | ≤ 0,30 | ≤ 0,30 | ≤ 0,08 | ≤ 0,020 | ≤ 0,30 | 0,03 | ≤ 0,02 | Cr+Cu+Mo +Ni: ≤ 0,70 |
| P355GH | 0,10 to 0,22 | ≤ 0,60 | 1,10 to 1,70 | 0,025 | 0,010 | ≥ 0,020 ^d | ≤ 0,012 ^d | ≤ 0,30 | ≤ 0,30 | ≤ 0,08 | ≤ 0,040 | ≤ 0,30 | 0,03 | ≤ 0,02 | — |
| 16Mo3 | 0,12 to 0,20 | ≤ 0,35 | 0,40 to 0,90 | 0,025 | 0,010 | e | ≤ 0,012 | ≤ 0,30 | ≤ 0,30 | 0,25 to 0,35 | — | ≤ 0,30 | — | — | — |
| 18MnMo4-5 | ≤ 0,20 | ≤ 0,40 | 0,90 to 1,50 | 0,015 | 0,005 | e | ≤ 0,012 | ≤ 0,30 | ≤ 0,30 | 0,45 to 0,60 | — | ≤ 0,30 | — | — | — |
| 20MnMoNi4-5 | 0,15 to 0,23 | ≤ 0,40 | 1,00 to 1,50 | 0,020 | 0,010 | e | ≤ 0,012 | ≤ 0,20 | ≤ 0,20 | 0,45 to 0,60 | — | 0,40 to 0,80 | — | ≤ 0,02 | — |
| 15NiCuMoNb5-6-4 | ≤ 0,17 | 0,25 to 0,50 | 0,80 to 1,20 | 0,025 | 0,010 | ≥ 0,015 | ≤ 0,020 | ≤ 0,30 | 0,50 to 0,80 | 0,25 to 0,50 | 0,015 to 0,045 | 1,00 to 1,30 | — | — | — |
| 13CrMo4-5 | 0,08 to 0,18 | ≤ 0,35 | 0,40 to 1,00 | 0,025 | 0,010 | e | ≤ 0,012 | 0,70 ^f to 1,15 | ≤ 0,30 | 0,40 to 0,60 | — | — | — | — | — |
| 13CrMoSi5-5 | ≤ 0,17 | 0,50 to 0,80 | 0,40 to 0,65 | 0,015 | 0,005 | e | ≤ 0,012 | 1,00 to 1,50 | ≤ 0,30 | 0,45 to 0,65 | — | ≤ 0,30 | — | — | — |
| 10CrMo9-10 | 0,08 to 0,14 ^g | ≤ 0,50 | 0,40 to 0,80 | 0,020 | 0,010 | e | ≤ 0,012 | 2,00 to 2,50 | ≤ 0,30 | 0,90 to 1,10 | — | — | — | — | — |
| 12CrMo9-10 | 0,10 to 0,15 | ≤ 0,30 | 0,30 to 0,80 | 0,015 | 0,010 | 0,010 to 0,040 | ≤ 0,012 | 2,00 to 2,50 | ≤ 0,25 | 0,90 to 1,10 | — | ≤ 0,30 | — | — | — |
| X12CrMo5 | 0,10 to 0,15 | ≤ 0,50 | 0,30 to 0,60 | 0,020 | 0,005 | e | ≤ 0,012 | 4,00 to 6,00 | ≤ 0,30 | 0,45 to 0,65 | — | ≤ 0,30 | — | — | — |