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

**Part 6:
Weldable fine grain steels, quenched
and tempered**

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

Partie 6: Aciers soudables à grains fins, trempés et revenus



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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 10, *Steel for pressure purposes*.

This third edition cancels and replaces the second edition (ISO 9328-6:2011), which has been technically revised. The following changes have been made:

- the term “product thickness” has been replaced with “nominal thickness”;
- the example of ordering has been revised;
- the technical data in [Annex A](#) have been aligned with EN 10028-6;
- in [Table B.1](#), the specifications of “P” and “S” have been changed.
- the content of the document has been generally updated.

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 6: Weldable fine grain steels, quenched and tempered

1 Scope

This document specifies the requirements for flat products for pressure equipment made of quenched and tempered weldable fine grain steels as specified in [Tables A.1](#) and [B.1](#). The requirements and definitions of ISO 9328-1 also apply to this document.

NOTE 1 Fine grain steels are understood to be steels with a ferritic grain size of 6 or finer when tested in accordance with ISO 643.

NOTE 2 This document offers the possibility of specifying products in accordance with European design codes and ASME-type design codes.

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, all steel grades covered by this document are alloyed special steels.

4.2 Designation

Shall be in accordance with ISO 9328-1.

This document covers the steel grades specified in [Annexes A](#) and [B](#) in four series:

- a) basic series (P...Q; PT...Q);
- b) series with elevated temperature properties (P...QH, PT...QH);
- c) series with low temperature properties down to $-40\text{ }^{\circ}\text{C}$ (P...QL1);
- d) series with low temperature properties down to $-60\text{ }^{\circ}\text{C}$ (P...QL2, PT...QL2).

NOTE 1 The steel grades in [Annex A](#) are classified in accordance with their yield strength; the steel 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.

Additionally, for steel grades in accordance with [Annex B](#), the test direction for the impact test shall be agreed upon (see [Clause 9](#) and [Table B.3](#), footnote a).

5.2 Options

A number of options are specified in this document. These are listed below under a) to j). 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) carbon-equivalent value (see [6.3.3](#));
- b) tensile properties at elevated temperatures for steel grades PT...QH (see [6.4](#));
- c) specification of an impact energy of 40 J (see the Note to [6.4](#) and [Table A.3](#));
- d) lower copper content and maximum tin content (see [Table A.1](#), footnote c);
- e) mechanical properties for thicknesses $> 150\text{ mm}$ (see [Table A.2](#), footnote b);
- f) applicability of elevated temperature values for QL grades (see [Table A.4](#), footnote b);
- g) increased maximum carbon content for the grade PT520Q (see [Table B.1](#), footnote c);
- h) increased maximum carbon content for the grade PT550QL2 (see [Table B.1](#), footnote d);
- i) other test requirements for the impact test (see [Table B.3](#), footnote b);
- j) tests on simulated heat-treated samples (see [6.7.2](#)).

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 P355QL2 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 9328-6 P355QL2 – Inspection certificate 3.1

6 Requirements

6.1 Steelmaking process

Shall be in accordance with ISO 9328-1.

6.2 Delivery condition

The products complying with this document are supplied in the quenched and tempered condition.

6.3 Chemical composition

6.3.1 The data in [Tables A.1](#) and [B.1](#) apply for the chemical composition according to the cast (heat) analysis.

6.3.2 The product analysis may deviate from the specified values of the cast (heat) analysis given in [Tables A.1](#) and [B.1](#) by the values given in [Table 1](#).

6.3.3 For the steel grades covered by this document, a carbon-equivalent value (CEV) may be specified at the time of enquiry and order. This shall be based on [Formula \(1\)](#):

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

6.4 Mechanical properties

The values given in [Tables A.2](#) to [A.4](#), as well as in [Tables B.2](#) and [B.3](#), apply (see also ISO 9328-1).

Additionally, for PT...QH steels (see [Annex B](#)), tensile properties at elevated temperatures may be agreed upon at the time of enquiry and order.

NOTE Optionally, a minimum impact energy value of 40 J can be specified for temperatures where lower minimum values are specified (see [Table A.3](#), footnote a).

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 steels specified in this document shall be suitable for welding processes in current use (see [6.7.2](#)).

6.7.2 The manufacturer shall, if requested, provide the purchaser with data on suitable welding conditions determined on the basis of weld procedure tests.

With increasing nominal thickness and strength level, cold cracking can occur. Cold cracking is caused by the following factors in combination:

- the amount of diffusible hydrogen in the weld metal;
- brittle structure of the heat-affected zone;
- tensile stress concentrations in the welded joint.

When using recommendations as laid down in appropriate documents, e.g. EN 1011-1 and EN 1011-2 or IIS/IIW 382-71, the recommended welding conditions and the various welding ranges of the steel grades can be determined depending on the nominal thickness, the applied welding energy, the design requirements, the electrode efficiency, the welding process and the weld metal properties.

Excessive post-weld heat treatment (PWHT) conditions may decrease the mechanical properties. The purchaser should, in his enquiry and order, inform the manufacturer accordingly.

Where appropriate, tests on simulated post-weld heat-treated samples may be agreed upon 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 10).

Table 1 — Permissible deviations of the chemical composition in the results of the product analysis from the specified values applicable to the cast (heat) analysis

Element	Specified value in the cast analysis according to Tables A.1 and B.1	Permissible deviation ^a of the product analysis
	% by mass	% by mass
C ^b	≤ 0,24	+0,02
Si	≤ 0,80	+0,05
Mn	≤ 1,70	+0,10
Pb	≤ 0,030	+0,005
Sb	≤ 0,010	+0,003
	> 0,010 to ≤ 0,030	+0,005
Al	≤ 0,020	−0,005
B	≤ 0,005	+0,000 5
N	≤ 0,020	+0,002
Cr	≤ 1,50	+0,10
Cu	≤ 0,40	+0,05
Mo	≤ 0,70	+0,04
Nb	≤ 0,06	+0,01
Ni	≤ 2,50	+0,10
Ti	≤ 0,05	+0,01
V	≤ 0,12	+0,01
Zr	≤ 0,15	+0,01

^a If several product analyses are carried out on one cast, and the contents of an individual element, as determined, lie outside the permissible range of the chemical composition specified for the cast (heat) analysis, then it is allowed either to exceed the permissible maximum value or to 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.

6.8 Dimensions and tolerances

Shall be in accordance with ISO 9328-1.

6.9 Calculation of mass

Shall be in accordance with ISO 9328-1.

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.

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

Shall be in accordance with ISO 9328-1.

Impact tests for verification of impact energy values in [Tables A.3](#) and [B.3](#) shall be carried out on transverse test pieces (for steel grades in accordance with [Annex A](#)) or on test pieces as specified in the order (for steel grades in accordance with [Annex B](#); see [Table B.3](#), footnote a).

10 Marking

Shall be in accordance with ISO 9328-1.

Annex A
(normative)

**Chemical composition and mechanical properties of products
delivered in accordance with European design codes**

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

Steel grade	Maximum contents % by mass														
	C	Si	Mn	P	S	N	B	Cr	Mo	Cu ^b	Nb ^c	Ni	Ti ^c	V ^c	Zr ^c
P355Q, P355QH	0,16	0,40	1,50	0,025	0,010	0,015	0,005	0,30	0,25	0,30	0,05	0,50	0,03	0,06	0,05
P355QL1				0,020	0,008										
P355QL2				0,005											
P460Q, P460QH	0,18	0,50	1,70	0,025	0,010	0,015	0,005	0,50	0,50	0,30	0,05	1,00	0,03	0,08	0,05
P460QL1				0,020	0,008										
P460QL2				0,005											
P500Q, P500QH	0,18	0,60	1,70	0,025	0,010	0,015	0,005	1,00	0,70	0,30	0,05	1,50	0,05	0,08	0,15
P500QL1				0,020	0,008										
P500QL2				0,005											
P690Q, P690QH	0,20	0,80	1,70	0,025	0,010	0,015	0,005	1,50	0,70	0,30	0,06	2,50	0,05	0,12	0,15
P690QL1				0,020	0,008										
P690QL2				0,005											
a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser, except for finishing the cast. All appropriate measures shall be taken to prevent the addition of these elements from scrap and other materials used in steelmaking, which may adversely affect the mechanical properties and usability.															
b For reasons of hot formability, a lower copper content and a maximum tin content may be agreed upon at the time of enquiry and order.															
c The percentage of grain-refining elements shall be at least 0,015 %. Aluminium is also included in these elements. The minimum content of 0,015 % applies here to dissolved aluminium. This value is regarded as attained if the total aluminium content is at least 0,018 %; in cases of dispute, the dissolved aluminium content shall be determined.															

^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser, except for finishing the cast. All appropriate measures shall be taken to prevent the addition of these elements from scrap and other materials used in steelmaking, which may adversely affect the mechanical properties and usability.

^b For reasons of hot formability, a lower copper content and a maximum tin content may be agreed upon at the time of enquiry and order.

^c The percentage of grain-refining elements shall be at least 0,015 %. Aluminium is also included in these elements. The minimum content of 0,015 % applies here to dissolved aluminium. This value is regarded as attained if the total aluminium content is at least 0,018 %; in cases of dispute, the dissolved aluminium content shall be determined.

Table A.2 — Mechanical properties at room temperature

Steel grade	Yield strength ^a			Tensile strength		Elongation after fracture
	R_{eH} MPa ^c min.			R_m MPa ^c		A % min.
	for nominal thickness, t , in mm			for nominal thickness, t , in mm		
	$t \leq 50$	$50 < t \leq 100$	$100 < t \leq 200^b$	$t \leq 100$	$100 < t \leq 200^b$	
P355Q, P355QH, P355QL1, P355QL2	355	335	315	490 to 630	450 to 590	22
P460Q, P460QH, P460QL1, P460QL2	460	440	400	550 to 720	500 to 670	19
P500Q, P500QH, P500QL1, P500QL2	500	480	440	590 to 770	540 to 720	17
P690Q, P690QH, P690QL1, P690QL2	690	670	630	770 to 940	720 to 900	14
^a The yield strength to be determined shall be the upper yield strength R_{eH} or, if this is not pronounced, the 0,2 % proof strength $R_{p0,2}$.						
^b Other nominal thicknesses may be agreed upon at the time of enquiry and order.						
^c 1 MPa = 1 N/mm ² .						

Table A.3 — Impact energy (valid for transverse V-notched test pieces)

Steel grades of the series	Nominal thickness t in mm	Impact energy				
		KV				
		in J				
		min.				
		at a temperature in °C of				
		-60	-40	-20	0	+20
P...Q, P...QH	≤ 200	—	—	27 ^a	40	60
P...QL1		—	27 ^a	40	60	—
P...QL2		27 ^a	40	60	80	—
^a An impact energy value of 40 J may be agreed upon at the time of enquiry and order.						

Table A.4 — Minimum 0,2 % proof strength $R_{p0,2}$ at elevated temperatures^a

Steel grade ^b	Minimum proof strength values ^c					
	$R_{p0,2}$ MPa ^d					
	at a temperature in °C of					
	50	100	150	200	250	300
P355QH	340	310	285	260	235	215
P460QH	445	425	405	380	360	340
P500QH	490	470	450	420	400	380
P690QH	670	645	615	595	575	570
^a The values shall be proven on request (see ISO 9328-1) for the specified service temperature. ^b If agreed upon at the time of enquiry and order, these values also apply to the grades P...QL with specified low temperature properties. ^c These values are valid for nominal thicknesses $t \leq 50$ mm. For larger specified thicknesses, the minimum 0,2 % proof strength values are reduced by 20 MPa for $50 \text{ mm} < t \leq 100$ mm, and by 60 MPa for $t > 100$ mm. ^d 1 MPa = 1 N/mm ² .						

Annex B (normative)

Chemical composition and mechanical properties of products delivered in accordance with ASME-type design codes

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

Steel grade	% by mass ^a													
	C	Si	Mn	P	S	Al ^{total} _b	B	Cr	Cu	Mo	Nb	Ni	Ti	V
	max.	max.		max.	max.	min.	max.	max.	max.	max.	max.	max.	max.	max.
PT440QL2	0,16	0,55	0,70 to 1,60	0,015	0,010	0,020	0,005	0,30	0,40	0,25	0,05	0,50	0,03	0,06
PT490Q, PT490QH	0,18	0,55	≤ 1,60	0,020	0,020	0,020	0,005	0,30	0,40	0,25	0,05	0,50	0,03	0,06
P490QL2	0,18	0,55	0,70 to 1,60	0,015	0,010	0,020	0,005	0,30	0,40	0,25	0,05	0,50	0,03	0,06
PT520Q, PT520QH	0,18c	0,55	≤ 1,60	0,020	0,020	0,020	0,005	0,30	0,40	0,25	0,05	0,50	0,03	0,06
PT520QL2	0,18	0,55	0,70 to 1,60	0,015	0,010	0,020	0,005	0,30	0,40	0,25	0,05	0,50	0,03	0,06
PT550Q, PT550QH	0,18	0,75	≤ 1,60	0,020	0,020	0,020	0,005	0,30	0,40	0,50	0,05	0,50	0,03	0,08
PT550QL2	0,18d	0,50	0,70 to 1,60	0,015	0,010	0,020	0,005	0,30	0,40	0,50	0,05	1,00	0,03	0,08
PT570Q, PT570QH	0,18	0,75	≤ 1,60	0,020	0,020	0,020	0,005	0,30	0,40	0,50	0,05	1,00	0,03	0,08
PT610Q, PT610QH	0,18	0,75	≤ 1,60	0,030	0,030	0,020	0,005	0,30	0,40	0,50	0,05	1,00	0,03	0,08
^a Elements not listed in this table shall not be intentionally added to the steel without the agreement of the purchaser, except for finishing the cast. All appropriate measures shall be taken to prevent the addition of these elements from scrap and other materials used in steelmaking, which may adversely affect the mechanical properties and usability. ^b On cast (heat) analysis, the aluminium content shall be not less than 0,020 % total aluminium or, alternatively, 0,015 % acid-soluble aluminium. ^c By agreement at the time of enquiry and order, the maximum carbon content may be increased to 0,20 %. ^d By agreement at the time of enquiry and order, the maximum carbon content may be increased to 0,24 %.														