

Flat products made of steels for pressure purposes

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

ICS 77.140.30; 77.140.50

National foreword

This British Standard is the UK implementation of EN 10028-6:2009. It supersedes BS EN 10028-6:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/73/2, Steel plates and bars for pressure purposes.

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

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Weldable fine grain steels, quenched and tempered**

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Aciers soudables à grains fins, trempés et revenus

Flacherzeugnisse aus Druckbehälterstählen - Teil 6:
Schweißgeeignete Feinkornbaustähle, vergütet

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Foreword

This document (EN 10028-6:2009) has been prepared by Technical Committee ECISS/TC 22 "Steels for pressure purposes - Qualities", 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of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

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

This document supersedes EN 10028-6:2003.

This European Standard consists of the following parts, under the general title *Flat products made of steels for pressure purposes*:

- *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*

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

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 97/23/EC.

For relationship with EU Directive 97/23/EC, see informative Annex ZA, which is an integral part of this document.

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, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard specifies the requirements for flat products for pressure equipments made of quenched and tempered steels as specified in Table 1.

The requirements in EN 10028-1:2007 + A1:2009 also apply.

NOTE Once this European Standard is published in the EU Official Journal (OJEU) under Directive 97/23/EC, presumption of conformity to the Essential Safety Requirements (ESRs) of Directive 97/23/EC is limited to technical data of materials in this European Standard (Part 1 and this Part 6 of the series) and does not presume adequacy of the material to a specific item of equipment. Consequently, the assessment of the technical data stated in this material standard against the design requirements of this specific item of equipment to verify that the ESRs of Directive 97/23/EC are satisfied, needs to be done.

2 Normative references

The following referenced 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.

EN 10028-1:2007 + A1:2009, *Flat products made of steels for pressure purposes – Part 1: General requirements*

EN 10204:2004, *Metallic products – Types of inspection documents*

3 Terms and definitions

For the purposes of this document the terms and definitions given in EN 10028-1:2007 + A1:2009 apply.

4 Dimensions and tolerances

See EN 10028-1:2007 + A1:2009.

5 Calculation of mass

See EN 10028-1:2007 + A1:2009.

6 Classification and designation

6.1 Classification

6.1.1 This document covers the steel grades given in Table 1 in four qualities:

- a) the basic series (P...Q);
- b) series with elevated temperature properties (P...QH);
- c) series with low temperature properties down to -40 °C (P...QL1);
- d) series with low temperature properties down to -60 °C (P...QL2).

6.1.2 In accordance with EN 10020 all the steels specified in this document are alloy special steels.

6.2 Designation

See EN 10028-1:2007 + A1:2009.

7 Information to be supplied by the purchaser

7.1 Mandatory information

See EN 10028-1:2007 + A1:2009.

7.2 Options

A number of options is specified in this document and listed below. Additionally the relevant options of EN 10028-1:2007 + A1:2009 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 also EN 10028-1:2007 + A1:2009).

- 1) providing data on suitable welding conditions (see 8.2.3);
- 2) mid thickness test pieces for the impact test (see Clause 10);
- 3) lower copper content and maximum tin content (see Table 1, footnote c);
- 4) mechanical properties for thicknesses > 150 mm (see Table 3, footnote b);
- 5) specification of a minimum impact energy of 40 J (see Note to 8.4 and Table 4, footnote a);
- 6) applicability of elevated temperature values for QL grades (see Table 5, footnote b).

7.3 Example for ordering

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 and the number 1.8869 as specified in EN 10028-6, inspection certificate 3.1 as specified in EN 10204:

10 plates – 50 x 2 000 x 10 000 – EN 10028-6 P355QL2 – Inspection certificate 3.1

or

10 plates – 50 x 2 000 x 10 000 – EN 10028-6 1.8869 – Inspection certificate 3.1.

8 Requirements

8.1 Steelmaking process

See EN 10028-1:2007 + A1:2009.

8.2 Delivery condition

8.2.1 The products covered by this European Standard shall be supplied in the quenched and tempered condition.

8.2.2 The steels specified in this European Standard shall be suitable for welding processes in current use (see Notes 1 to 3 to 8.2.3).

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

NOTE 1 With increasing product thickness and strength level cold cracking can occur. Cold cracking is caused by the following factors in combination:

- a) the amount of diffusible hydrogen in the weld metal;
- b) brittle structure of the heat affected zone;

c) tensile stress concentrations in the welded joint.

NOTE 2 When using recommendations as laid down, for example in EN 1011-1 and EN 1011-2, the recommended welding conditions and the various welding ranges of the steel grades can be determined depending on the product thickness, the applied welding energy, the design requirements, the electrode efficiency, the welding process and the weld metal properties.

NOTE 3 Excessive post weld heat-treatment (PWHT) conditions can decrease the mechanical properties. It is therefore recommended that the purchaser seeks, at the time of enquiry and order, the advice of the manufacturer and considers, where appropriate, the verification of the mechanical properties on simulated post weld heat treated samples.

8.3 Chemical composition

8.3.1 The requirements of Table 1 apply for the chemical composition according to the cast analysis.

8.3.2 The product analysis may deviate from the specified values of the cast analysis given in Table 1 by the values given in Table 2.

8.4 Mechanical properties

The values given in Tables 3 to 5 apply (see also EN 10028-1:2007 + A1:2009 and Clause 10).

NOTE Optionally, a minimum impact energy value of 40 J may be specified for temperatures where lower minimum values are specified (see Table 4, footnote a).

8.5 Surface condition

See EN 10028-1:2007 + A1:2009.

8.6 Internal soundness

See EN 10028-1:2007 + A1:2009.

For possible verification, see also EN 10028-1:2007 + A1:2009.

9 Inspection

9.1 Types of inspections and inspections documents

See EN 10028-1:2007 + A1:2009.

9.2 Tests to be carried out

See EN 10028-1:2007 + A1:2009.

9.3 Retests

See EN 10028-1:2007 + A1:2009.

10 Sampling

See EN 10028-1:2007 + A1:2009.

For the impact test, deviating from EN 10028-1:2007 + A1:2009, Table 3, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

11 Test methods

See EN 10028-1:2007 + A1:2009.

12 Marking

See EN 10028-1:2007 + A1:2009.

Table 1 — Chemical composition (cast analysis)^{a,b}

Steel grade		Maximum contents, % by mass														
Steel name	Steel number	C	Si	Mn	P	S	N	B	Cr	Mo	Cu ^c	Nb ^d	Ni	Ti ^d	V ^d	Zr ^d
P355Q	1.8866	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
P355QH	1.8867				0,020	0,008										
P355QL1	1.8868					0,005										
P355QL2	1.8869															
P460Q	1.8870	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
P460QH	1.8871				0,020	0,008										
P460QL1	1.8872					0,005										
P460QL2	1.8864															
P500Q	1.8873	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
P500QH	1.8874				0,020	0,008										
P500QL1	1.8875					0,005										
P500QL2	1.8865															
P690Q	1.8879	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
P690QH	1.8880				0,020	0,008										
P690QL1	1.8881					0,005										
P690QL2	1.8888															

^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 from scrap and other materials used in steelmaking of these elements which may adversely affect the mechanical properties and usability.

^b The manufacturer may add one or several alloying element(s) up to the maximum values specified in the order as a function of the product thickness and the steelmaking conditions in order to attain the specified properties. The chemical composition range for each manufacturer's analysis shall be given in the offer and confirmation of order.

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

^d 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 is to be determined.

Table 2 — Permissible deviations of the chemical composition in the results of the product analysis from the specified values applicable to the cast analysis

Element	Specified value in the cast analysis according to Table 1 % by mass	Permissible deviation ^a of the product analysis % by mass
C	≤ 0,20	+ 0,02
Si	≤ 0,80	+ 0,05
Mn	≤ 1,70	+ 0,10
P	≤ 0,025	+ 0,005
S	≤ 0,010	+ 0,003
Al _{total}	≥ 0,018	- 0,005
N	≤ 0,015	+ 0,002
B	≤ 0,005	+ 0,0005
Cr	≤ 1,50	+ 0,10
Mo	≤ 0,70	+ 0,04
Cu	≤ 0,30	+ 0,05
Ni	≤ 2,50	+ 0,10
Nb	≤ 0,06	+ 0,01
Ti	≤ 0,05	+ 0,01
V	≤ 0,12	+ 0,01
Zr	≤ 0,15	+ 0,01

^a If several product analysis are carried out on one cast, and then 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.

Table 3 — Mechanical properties at room temperature

Steel grade		Yield strength ^a R_{eH} for product thickness t in mm			Tensile strength R_m for product thickness t in mm		Elongation after fracture A % min.
		$t \leq 50$	$50 < t \leq 100$	$100 < t \leq 150^b$	$t \leq 100$	$100 < t \leq 150^b$	
Steel name	Steel number	MPa min.			MPa		
P355Q	1.8866	355	335	315	490 to 630	450 to 590	22
P355QH	1.8867						
P355QL1	1.8868						
P355QL2	1.8869						
P460Q	1.8870	460	440	400	550 to 720	500 to 670	19
P460QH	1.8871						
P460QL1	1.8872						
P460QL2	1.8864						
P500Q	1.8873	500	480	440	590 to 770	540 to 720	17
P500QH	1.8874						
P500QL1	1.8875						
P690QL2	1.8865						
P690Q	1.8879	690	670	630	770 to 940	720 to 900	14
P690QH	1.8880						
P690QL1	1.8881						
P460QL2	1.8888						

^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 product thicknesses may be agreed at the time of enquiry and order.

Table 4 — Impact energy (valid for transverse test pieces)

Steel grade	Product thickness mm	Impact energy KV J min. at a temperature in °C of				
		-60	-40	-20	0	+20
P...Q P...QH	≤ 150	—	—	27 ^a	40	60
P...QL1		—	27 ^a	40	60	—
P...QL2		27 ^a	40	60	80	—

^a •• A minimum impact energy value of 40 J may be agreed at the time of enquiry and order.

Table 5 — Minimum 0,2 % proof strength $R_{p0,2}$ at elevated temperatures^a

Steel grade ^b		Minimum 0,2 % proof strength $R_{p0,2}$ values ^c in MPa at a temperature in °C of					
Steel name	Steel number	50	100	150	200	250	300
P355QH	1.8867	340	310	285	260	235	215
P460QH	1.8871	445	425	405	380	360	340
P500QH	1.8874	490	470	450	420	400	380
P690QH	1.8880	670	645	615	595	575	570

^a The values shall be proven by means of a tensile test at elevated temperature for the specified service temperature. An agreement at the time of enquiry and order shall be reached on this between the purchaser and manufacturer.

^b •• If agreed 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 product thicknesses $t \leq 50$ mm. For larger thicknesses, the minimum 0,2 % proof strength values are reduced by:

- 20 MPa for $50 \text{ mm} < t \leq 100 \text{ mm}$ and by
- 60 MPa for $t > 100 \text{ mm}$.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard and the Essential Requirements of EU Directive 97/23/EC, Annex I

Clauses/sub-clauses of this European Standard	Essential Requirements (ERs) of Directive 97/23/EC, Annex I	Qualifying remarks/ Notes
8.4	4.1a	Appropriate material properties
8.2	4.1c	Ageing
8.2 and 8.6	4.1d	Suitable for the processing procedures
9.1	4.3	Documentation

WARNING: Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Bibliography

- [1] EN 1011-1, *Welding – Recommendations for welding of metallic materials – Part 1: General guidance for arc welding*
- [2] EN 1011-2, *Welding – Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels*
- [3] EN 10020, *Definition and classification of grades of steel*

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