INTERNATIONAL STANDARD

ISO 9328-3

Third edition
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Steel flat products for pressure purposes — Technical delivery conditions —

Part 3: Weldable fine grain steels, normalized

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

Partie 3: Aciers soudables à grains fins, normalisés

Reference number
ISO 9328-3:2011(E)

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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 9328-3 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 9328-3:2004), of which it constitutes a minor revision.

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 with a point (•) contain information relating to agreements that shall be made at the time of enquiry and order. Clauses and paragraphs 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 3: Weldable fine grain steels, normalized

1 Scope

This part of ISO 9328 specifies the requirements for flat products for pressure equipment made of 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 part of ISO 9328.

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

NOTE 2 This part of ISO 9328 offers the possibility to specifying products in accordance with European design codes and ASME-type design codes.

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.

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

4.1.1 The steel grades covered by this part of ISO 9328 are given in four qualities:

a) the room temperature quality (P...N; PT…N);

b) the elevated temperature quality (P...NH; PT…NH);

c) the low temperature quality (P...NL1; PT…NL1);

d) the special low temperature quality (P...NL2).

4.1.2 In accordance with ISO 4948-1 and ISO 4948-2, the grades P275NH, P275NL1, P355N, P355NH, P355NL1, PT400N, PT400NH, PT400NL1, PT440N, PT440NH, PT440NL1, PT490N and PT490NH are alloy-quality steels, the grades P275NL2 and P355NL2 are non-alloy special steels and the grades P460NH, P460NL1, P460NL2, PT520N and PT520NH are alloyed special steels.

4.2 Designation

See ISO 9328-1.

NOTE 1 Steel grades in Annex A are classified according to their yield strength; steel grades in Annex B are classified according to 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.

Additionally, for steel grades in accordance with Annex B, the test direction for the impact test shall be agreed upon (see 9.2 and Table B.4, footnote b).

5.2 Options

A number of options are specified in this part of ISO 9328. These are listed below under a) to q). 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) delivery condition other than specified in Tables A.3 and B.3 (see 6.2.1);

b) tests in the simulated normalized condition (see 6.2.2);

c) delivery of products in the untreated condition (see 6.2.3);

d) maximum carbon-equivalent value (see 6.3.3);

e) specification of an impact energy value of 40 J (see Note to 6.4.1 and Table A.3);

f) application of the $R_{p0,2}$ values of Table A.4 for the corresponding P…NL1 and P...NL2 grades (see 6.4.2);

g) test on simulated heat-treated samples (see 6.7.2);

h) hydrogen-induced cracking (HIC) test in accordance with Annex D (see 6.10);

i) mid-thickness test pieces for the impact test and/or tensile test (see Clause 8);

j) verification of impact energy for longitudinal test pieces (see 9.3);

k) tensile properties for increased product thicknesses (see Table A.3, footnote d);

l) $R_{p0,2}$ values at elevated temperatures for increased product thicknesses (see Table A.4, footnote c);

m) modified values for R_{eH} and R_m for grades P460NH and P460NL1 (see Table A.3, footnote f);

n) altered maximum value for Cr, Cu, Mo, Nb, Ni, Ti and V (see Table B.1, footnote b);

o) Al_{total} content $< 0{,}020$ % (see Table B.1, footnote c);

p) increased maximum carbon contents for grades PT…NH (see Table B.1, footnote d)

q) other test requirements for the impact test (see Table B.4, footnote c).

5.3 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 P275NL2 as specified in ISO 9328-3, to be delivered with inspection certificate 3.1.B as specified in ISO 10474:1991 is designated as follows:

10 plates — 50 × 2 000 × 10 000 — ISO 9328-3 P275NL2 — Inspection certificate 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 (see 6.2.3), the products covered by this part of ISO 9328 shall be supplied in the normalized condition.

For steels with a minimum yield strength ⩾ 460 MPa, delayed cooling or additional tempering may be necessary for small product thicknesses and in special cases. If such a treatment is performed, this shall be noted in the inspection document.

6.2.2 •• At the discretion of the manufacturer, normalizing may be replaced with normalizing rolling for the steel grades P275NH, P275NL1, P275NL2, P355N, P355NH, P355NL1 and P355NL2 (see Annex A and 3.1 in ISO 9328-1:2011). 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 •• If so agreed at the time of enquiry and order, products covered by this part of ISO 9328 may be delivered in the untreated condition.

6.2.4 For products delivered untreated, the specified tests shall be carried out on test pieces in the simulated normalized condition (but see 6.2.1).

NOTE Tests in a simulated heat-treated condition are carried out to verify the suitability of the final product in the usual delivery condition. 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 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 steel grades covered by this part of ISO 9328, a carbon-equivalent value according to Table A.2 (steel grades in Annex A) or Table B.2 (steel grades in Annex B) may be agreed upon at the time of enquiry and order.

Table 1 — Permissible deviations of the product analysis from the specified limits given in Tables A.1 and B.1 for the cast (heat) analysis

Element	Specified limit of the cast (heat) analysis according to Tables A.1 and B.1 % by mass	Permissible deviation[a] of the product analysis % by mass
C[b]	⩽ 0,20	+0,02
Si	⩽ 0,60	+0,06
Mn	⩽ 1,00	±0,05
	> 1,00 to ⩽ 1,70	±0,10
P[b]	⩽ 0,030	+0,005
S[b]	⩽ 0,010	+0,003
	> 0,010 to ⩽ 0,030	+0,005
Al	⩾ 0,020	–0,005
N	⩽ 0,025	+0,002
Cr	⩽ 0,30	+0,05
Mo	⩽ 0,12	+0,03
Cu	⩽ 0,30	+0,05
	> 0,30 to ⩽ 0,70	+0,10
Nb	⩽ 0,05	+0,01
Ni	⩽ 0,80	+0,05
Ti	⩽ 0,03	+0,01
V	⩽ 0,20	+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 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 the 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.3 to A.5 and Tables B.3 and B.4 (see also ISO 9328-1 and Clause 8) shall apply.

NOTE Optionally, a minimum impact energy value of 40 J can be specified for temperatures where lower minimum values are specified (see Table A.5, footnote d)

6.4.2 •• By agreement at the time of enquiry and order, the minimum proof strength $R_{p0,2}$ values at elevated temperature specified in Table A.4 for the P...NH grades may also be applied to the P…NL1 and P...NL2 grades.

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 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, on 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 (for Annex A steel grades) the critical value $P_{crit.}$ of

— 17,3 for all steel grades except P460NH, P460NL1 and P460NL2,

— 16,7 in the case of steel grade P460NH, and

— 16,3 in the case of steel grades P460NL1 and P460NL2,

(for Annex B grades, other specific values may apply), 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 part of ISO 9328 can still be regarded as valid.

6.8 Dimensions and tolerances

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 H_2S-containing environments, usually referred to as “sour service”.

•• A test to evaluate the resistance to hydrogen-induced (HIC) cracking in accordance with Annex D or another agreed test method may be agreed upon at the time of enquiry and order.

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.

7.3 Retests

See ISO 9328-1.

8 Sampling

See ISO 9328-1.

•• For the impact test and/or 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 Annex D.

9.2 • Impact tests for verification of impact energy values in Tables A.5 and B.4 shall be carried out on transverse test pieces (for steel grades in accordance with Annex A, but see 9.3) or on test pieces as specified in the order (for steel grades in accordance with Annex B; see Table B.4, footnote b).

9.3 •• For the impact test, verification of impact energy for longitudinal test pieces may be agreed upon at the time of enquiry and order for steel grades in accordance with Annex A.

10 Marking

See ISO 9328-1.

Annex A
(normative)

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

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

Steel name	% by mass[a]														
	C max.	**Si** max.	**Mn**	**P** max.	**S** max.	**Al_{total}** min.	**N** max.	**Cr** max.	**Cu** max.	**Mo** max.	**Nb** max.	**Ni** max.	**Ti** max.	**V** max.	**Nb + Ti + V** max.
P275NH	0,16	0,40	0,80[b] to 1,50	0,025	0,010	0,020[c,d]	0,012	0,30[e]	0,30[e]	0,08[e]	0,05	0,50	0,03	0,05	0,05
P275NL1					0,008										
P275NL2				0,020	0,005										
P355N	0,18	0,50	1,10 to 1,70	0,025	0,010	0,020[c,d]	0,012	0,30[e]	0,30[e]	0,08[e]	0,05	0,50	0,03	0,10	0,12
P355NH															
P355NL1					0,008										
P355NL2				0,020	0,005										
P460NH	0,20	0,60	1,10 to 1,70	0,025	0,010	0,020[d]	0,025	0,30	0,70[f]	0,10	0,05	0,80	0,03	0,20	0,22
P460NL1					0,008										
P460NL2				0,020	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 or other materials used in steelmaking, which may adversely affect the mechanical properties and usability.

[b] For product thicknesses < 6 mm, a minimum Mn content of 0,60 % is permitted.

[c] The Al_{total} content may fall short of this minimum if niobium, titanium or vanadium are additionally used for nitrogen binding.

[d] If only aluminium is used for nitrogen binding, a ratio Al:N $\geqslant$ 2 shall apply.

[e] The sum of the percentages by mass of the three elements chromium, copper and molybdenum shall not exceed 0,45 %.

[f] If the percentage by mass of copper exceeds 0,30 %, the percentage by mass of nickel shall be at least half the percentage by mass of copper.

Table A.2 — Maximum carbon-equivalent value (CEV) based on cast (heat) analysis
(if agreed upon at the time of enquiry and order)[a]

Steel name	CEV[b] max. for product thicknesses, t, in mm		
	$\leqslant 60$	$60 < t \leqslant 100$	$100 < t \leqslant 250$
P275NH	0,40	0,40	0,42
P275NL1			
P275NL2			
P355N	0,43	0,45	0,45
P355NH			
P355NL1			
P355NL2			
P460NH	0,53	—	
P460NL1			
P460NL2			

NOTE The values for the carbon equivalent are based on the percentage by mass and relate to the mechanical properties specified for the delivery condition.

[a] See 6.3.3.

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

Table A.3 — Tensile properties at room temperature

Steel name	Usual delivery condition[a,b]	Product thickness t mm	Yield strength R_{eH} MPa[e] min.	Tensile strength R_m MPa[e]	Elongation after fracture A % min.
P275NH, P275NL1, P275NL2	+N[b]	$\leqslant 16$	275	390 to 510	24
		$16 < t \leqslant 40$	265		
		$40 < t \leqslant 60$	255		
		$60 < t \leqslant 100$	235	370 to 490	23
		$100 < t \leqslant 150$	225	360 to 480	
		$150 < t \leqslant 250$	215	350 to 470	
P355N, P355NH, P355NL1, P355NL2	+N[b]	$\leqslant 16$	355	490 to 630	22
		$16 < t \leqslant 40$	345		
		$40 < t \leqslant 60$	335		
		$60 < t \leqslant 100$	315	470 to 610	21
		$100 < t \leqslant 150$	305	460 to 600	
		$150 < t \leqslant 250$	295	450 to 590	
P460NH, P460NL1, P460NL2	+N	$\leqslant 16$[f]	460	570 to 720[c]	17
		16[f] $< t \leqslant 40$	445		
		$40 < t \leqslant 60$	430		
		$60 < t \leqslant 100$	400	540 to 710	
		$100 < t \leqslant 250$	[d]	[d]	[d]

[a] +N: normalized; other delivery conditions by agreement (see 6.2.1 and 6.2.3).

[b] See 6.2.2.

[c] For product thicknesses up to 16 mm, a maximum value of 730 MPa is permitted.

[d] •• Values may be agreed upon at the time of enquiry and order.

[e] 1 MPa = 1 N/mm^2

[f] •• In the case of P460NH and P460NL1, up to a product thickness of 20 mm, a minimum R_{eH} of 460 MPa and an R_m range of 630 MPa to 725 MPa may be agreed upon at the time of enquiry and order.

Table A.4 — Minimum values for the proof strength $R_{p0,2}$ at elevated temperatures[a]

Steel name	Product thickness t mm	Minimum proof strength $R_{p0,2}$ MPa[b] at a temperature in °C of							
		50	100	150	200	250	300	350	400
P275NH	$\leqslant 16$	266	250	232	213	195	179	166	156
	$16 < t \leqslant 40$	256	241	223	205	188	173	160	150
	$40 < t \leqslant 60$	247	232	215	197	181	166	154	145
	$60 < t \leqslant 100$	227	214	198	182	167	153	142	133
	$100 < t \leqslant 150$	218	205	190	174	160	147	136	128
	$150 < t \leqslant 50$	208	196	181	167	153	140	130	122
P355NH	$\leqslant 16$	343	323	299	275	252	232	214	202
	$16 < t \leqslant 40$	334	314	291	267	245	225	208	196
	$40 < t \leqslant 60$	324	305	282	259	238	219	202	190
	$60 < t \leqslant 100$	305	287	265	244	224	206	190	179
	$100 < t \leqslant 150$	295	277	257	236	216	199	184	173
	$150 < t \leqslant 250$	285	268	249	228	209	192	178	167
P460NH	$\leqslant 16$	445	419	388	356	326	300	278	261
	$16 < t \leqslant 40$	430	405	375	345	316	290	269	253
	$40 < t \leqslant 60$	416	391	362	333	305	281	260	244
	$60 < t \leqslant 100$	387	364	337	310	284	261	242	227
	$100 < t \leqslant 250$	c	c	c	c	c	c	c	c

a The values reflect the minimum values for furnace-normalized test pieces (i.e. they correspond to the lower band of the relevant trend curve determined in accordance with EN 10314) with a confidence limit of about 98 % (2s).

b 1 MPa = 1 N/mm^2.

c •• Values may be agreed upon.

Table A.5 — Minimum impact energy values for the normalized condition[a]

Steel name	Product thickness t mm	Impact energy KV J min. transverse / longitudinal[b] at a temperature in °C of									
		–50	–40	–20	0	+20	–50	–40	–20	0	+20
P355N, P...NH	$\leqslant 250$[c]	—	—	30[d]	40	50	—	—	45	65	75
P…NL1		—	27[d]	35[d]	50	60	30[d]	40	50	70	80
P...NL2		27[d]	30[d]	40	60	70	42	45	55	75	85

a See 6.2.1 to 6.2.4.

b The values apply for product thicknesses $\leqslant 40$ mm.

c For the grades P460NH, P460NL1 and P460NL2, up to product thicknesses of 100 mm.

d •• An impact energy value of 40 J may be agreed upon at the time of enquiry and order.

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 max.	Si max.	Mn	P max.	S max.	Al_{total} min.[c]	Cr max.[b]	Cu max.[b]	Mo max.[b]	Nb max.[b]	Ni max.[b]	Ti max.[b]	V max.[b]	Others
PT400N, PT400NH	0,18[d]	⩽ 0,40	⩽ 1,40	0,030	0,030	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,05	Cr + Cu + Mo + Ni: ⩽ 1,00[b]
PT400NL1	0,15	⩽ 0,40	0,70 to 1,50	0,025	0,020	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,05	Cr + Cu + Mo + Ni: ⩽ 1,00[b]
PT440N, PT440NH	0,18[d]	⩽ 0,55	⩽1,60	0,030	0,030	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,10	Cr + Cu + Mo + Ni: ⩽ 1,00[b]
PT440NL1	0,16	⩽ 0,55	0,70 to 1,60	0,025	0,020	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,10	Cr + Cu + Mo + Ni: ⩽ 1,00[b]
PT490N, PT490NH	0,18[d]	0,15 to 0,55	⩽ 1,60	0,030	0,030	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,10	Cr + Cu + Mo + Ni: ⩽ 1,00[b]
PT520N, PT520NH	0,20	0,15 to 0,55	⩽ 1,60	0,030	0,030	0,020	0,30	0,40	0,12	0,05	0,80	0,03	0,10	Cr + Cu + Mo + Ni: ⩽ 1,00[b]

[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 or other materials used in steelmaking, which may adversely affect the mechanical properties and usability.

[b] •• Other maximum contents for Cr, Cu, Mo, Nb, Ni, Ti and V may be agreed upon at the time of enquiry and order.

[c] On cast analysis, the aluminium content shall be not less than 0,020 % total aluminium or, alternatively, 0,015 % acid-soluble aluminium.

•• By agreement at the time of enquiry and order, the (total or soluble) aluminium content may fall short of this minimum if niobium, titanium or vanadium are additionally used for nitrogen binding.

[d] •• By agreement at the time of enquiry and order, the maximum carbon content may be increased up to 0,20 % in the case of PT400NH, and up to 0,24 % in the case of PT440NH and PT490NH.

Table B.2 — Maximum carbon-equivalent value (CEV) based on cast (heat) analysis
(if agreed upon at the time of enquiry and order)[a]

Steel grade	CEV[b] % max. for product thicknesses, t, in mm		
	$\leqslant 50$	$50 < t \leqslant 00$	$100 < t \leqslant 150$
PT400N, PT400NH, PT400NL1, PT440N, PT440NH, PT440NL1	0,41	0,43	0,43
PT490N, PT490NH	0,43	0,45	0,45
PT520N, PT520NH	0,45	0,47	0,47

NOTE The values for the carbon equivalent are based on the percentage by mass and relate to the mechanical properties specified for the delivery condition.

[a] See 6.3.3.

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

Table B.3 — Tensile properties at room temperature[a]

Steel grade	Usual delivery condition[b]	Product thickness t mm	Yield strength R_{eH} MPa[c] min.	Tensile strength R_m MPa[c]	Elongation after fracture A % min.
PT400N, PT400NH	+N	$6 \leqslant t \leqslant 50$	235	400 to 540	21
		$50 < t \leqslant 100$	215		
		$100 < t \leqslant 150$	195		
PT400NL1	+N	$6 \leqslant t \leqslant 40$	235	400 to 510	21
		$40 < t \leqslant 50$	215		
PT440N, PT440NH	+N	$6 \leqslant t \leqslant 50$	270	440 to 560	21
		$50 < t \leqslant 100$	250		
		$100 < t \leqslant 150$	230		
PT440NL1	+N	$6 \leqslant t \leqslant 38$	325	440 to 560	19
PT490N, PT490NH	+N	$6 \leqslant t \leqslant 50$	315	490 to 620	19
		$50 < t \leqslant 100$	295		
		$100 < t \leqslant 150$	275		
PT520N, PT520NH	+N	$6 \leqslant t \leqslant 50$	355	520 to 640	18
		$50 < t \leqslant 100$	335		
		$100 < t \leqslant 150$	315		

[a] Applicable for transverse direction.

[b] +N: normalized. See also 6.2.1 and 6.2.3.

[c] 1 MPa = 1 N/mm^2.

Table B.4 — Minimum impact energy values for the normalized condition[a]

Steel grade	Product thickness t mm	Impact energy[b,c] KV J min. at a temperature in °C of	
		–40	0
PT … N, PT … NH	$6 \leqslant t \leqslant 150$	—	47
PT … NL1	$6 \leqslant t \leqslant 50$[d]	47	—

a See 6.2.1 and 6.2.2.

b • For longitudinal or transverse test pieces, as agreed upon at the time of enquiry and order.

c •• Other test temperatures and minimum impact energy values may be agreed upon at the time of enquiry and order.

d For the grade PT440NL1, up to product thicknesses of 38 mm.

Annex C
(informative)

Steel designations in accordance with this part of ISO 9328 and designation of comparable steel grades in national or regional standards

Table C.1 — Steel designations in accordance with this part of ISO 9328[a] and designation of comparable[b] steel grades in national or regional standards

Steel designation in			
ISO 9328-3	EN 10028-3[c]	ASTM A537, A662	JIS G3115, G3126
P275NH	1.0487		
P275NL1	1.0488		
P275NL2	1.1104		
P355N	1.0562		
P355NH	1.0565		
P355NL1	1.0566		
P355NL2	1.1106		
P460NH	1.8935		
P460NL1	1.8915		
P460NL2	1.8918		
PT400N, PT400NH		A662A	SPV235
PT400NL1		A662A	SLA235A
PT440N, PT440NH		A662B	(SPV270)
PT440NL1		A537-1, A662B	SLA325A
PT490N, PT490NH		A662C	SPV315
PT520N, PT520NH			SPV355

[a] In accordance with ISO/TS 4949.

[b] "Comparable" covers both identical or similar steel grades.

[c] In addition to the steel name (identical to the corresponding steel name used in this part of ISO 9328), the listed steel number is specified.

Annex D
(normative)

Evaluation of resistance to hydrogen-induced cracking

D.1 A test to evaluate the resistance of steel products to hydrogen-induced cracking shall be performed.

D.2 The test procedure specified in EN 10229 or another appropriate procedure with specified acceptance criteria (e.g. in accordance with NACE TM0284) shall be applied.

D.3 The procedure to be applied, the test solution and the corresponding acceptance criteria shall be agreed upon at the time of enquiry and order.

In the case of the procedure specified in EN 10229, the acceptance criteria for test solution A (with pH ≈ 3) apply for the classes indicated in Table D.1, where the given values are mean values from three individual test results.

Table D.1 — Acceptance classes for the HIC test (test solution A)

Acceptance class	CLR[a] %	CTR[a] %	CSR[a] %
I	⩽ 5	⩽ 1,5	⩽ 0,5
II	⩽ 10	⩽ 3	⩽ 1
III	⩽ 15	⩽ 5	⩽ 2

[a] CLR: crack length ratio, CTR: crack thickness ratio, CSR: crack sensitivity ratio.

Bibliography

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

[2] ISO/TS 4949, *Steel names based on letter symbols*

[3] EN 1011-1, *Welding — Recommendations for welding of metallic materials — Part 1: General guidance for arc welding*

[4] EN 1011-2, *Welding — Recommendations for welding of metallic materials — Part 2: Arc welding of ferritic steels*

[5] IIS/IIW 382-71, *Guide to the welding and weldability of C-Mn steels and C-Mn microalloyed steels*

[6] NACE TM0284:2003, *Standard test method — Evaluation of pipeline and pressure vessel steels for resistance to hydrogen-induced cracking*

ICS 77.140.30; 77.140.50

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