
**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

STANDARDSISO.COM : Click to view the full PDF of ISO 9328-3:2018



STANDARDSISO.COM : Click to view the full PDF of ISO 9328-3:2018



COPYRIGHT PROTECTED DOCUMENT

© ISO 2018

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

Published in Switzerland

Contents

Page

Foreword	iv
1 Scope	1
2 Normative references	1
3 Terms and definitions	1
4 Classification and designation	1
4.1 Classification	1
4.2 Designation	2
5 Information to be supplied by the purchaser	2
5.1 Mandatory information	2
5.2 Options	2
5.3 Example for ordering	3
6 Requirements	3
6.1 Steelmaking process	3
6.2 Delivery condition	3
6.3 Chemical composition	3
6.4 Mechanical properties	4
6.5 Surface condition	4
6.6 Internal soundness	5
6.7 Weldability	5
6.8 Dimensions and tolerances	5
6.9 Calculation of mass	5
6.10 Resistance to hydrogen-induced cracking	5
7 Inspection	6
7.1 Types of inspection and inspection documents	6
7.2 Tests to be carried out	6
7.3 Retests, sorting and reprocessing	6
8 Sampling	6
9 Test methods	6
10 Marking	6
Annex A (normative) Chemical composition and mechanical properties of products delivered in accordance with European design codes	7
Annex B (normative) Chemical composition and mechanical properties of products delivered in accordance with ASME-type design codes	13
Annex C (informative) Steel designations in accordance with this document and designation of comparable steel grades in national or regional standards	17
Annex D (informative) Evaluation of resistance to hydrogen-induced cracking	18
Bibliography	19

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 fourth edition cancels and replaces the third edition (ISO 9328-3:2011), which has been technically revised. The following changes have been made:

- the term “product thickness” has been replaced with “nominal thickness”;
- classification of the steels, examples of ordering and statements concerning weldability have been revised;
- the technical data in [Annex A](#) have been aligned with EN 10028-3.
- in [Table B.1](#), “ $B \leq 0,004\ 0$ ” 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 3: Weldable fine grain steels, normalized

1 Scope

This document 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 document.

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 document offers the possibility to 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*

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.

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

4.1.1 The steel grades covered by this document 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, P355NL2, PT400N, PT400NH, PT400NL1, PT440N, PT440NH, PT440NL1, PT490N and PT490NH are alloy-quality steels, the grades P275NL2 and the grades P420NH, P420NL1, P420NL2, P460NH, P460NL1, P460NL2, PT520N and PT520NH are alloyed special steels.

4.2 Designation

Shall be in accordance with ISO 9328-1.

NOTE 1 Steel grades in [Annex A](#) are classified in accordance with their yield strength; 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 [9.2](#) and [Table B.4](#), footnote b).

5.2 Options

A number of options are specified in this document. These are listed below under a) to r). 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 nominal thicknesses (see [Table A.3](#), footnote d);
- l) $R_{p0.2}$ values at elevated temperatures for increased nominal 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);
- o) altered maximum value for Cr, Cu, Mo, Nb, Ni, Ti and V (see [Table B.1](#), footnote b);
- p) Al_{total} content < 0,020 % (see [Table B.1](#), footnote c);
- q) increased maximum carbon contents for grades PT...NH (see [Table B.1](#), footnote d);
- r) other test requirements for the impact test (see [Table B.4](#), footnote c).

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 P275NL2 as specified in this document, to be delivered with inspection certificate 3.1 as specified in ISO 10474, is designated as follows:

10 plates – 50 × 2 000 × 10 000 – ISO 9328-3 P275NL2 – 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 (see [6.2.3](#)), the products covered by this document shall be supplied in the normalized condition.

For steels with minimum yield strength ≥ 460 MPa, delayed cooling or additional tempering is permitted. 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 in [Annex A](#) (see ISO 9328-1:2018, 3.1). 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 2).

6.2.3 If so agreed at the time of enquiry and order, products covered by this document may be delivered in the untreated condition. The products delivered in untreated conditions shall be appropriately marked (+AR) to denote that heat treatment has not been performed.

6.2.4 For products delivered untreated, the specified tests shall be carried out by the manufacture 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 document, 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	Permissible deviation ^a of the product analysis
	% by mass	% 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
B	≤ 0,001 0	+0,000 5
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](#)).

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

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 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, on stress relieving, the intended time-temperature parameter shown by [Formula \(1\)](#):

$$P = T_s (20 + \lg t) \times 10^{-3} \quad (1)$$

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 P420NH, P420NL1, P420NL2, P460NH, P460NL1 and P460NL2,
- 16,7 in the case of steel grade P420NH, P460NH, and
- 16,3 in the case of steel grades P420NL1, P420NL2, 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 document can still be regarded as valid (see [5.2](#), Option 7).

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.

6.10 Resistance to hydrogen-induced cracking

Since 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 D](#) or another test method may be agreed at the time of enquiry and order.

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](#).

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 [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 E](#); 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

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**

STANDARDSISO.COM : Click to view the full PDF of ISO 9328-3:2018

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

Steel grade		% by mass ^a														
Steel name	Steel number	C	Si	Mn	P	S	Al ^{total}	N	Cr	Cu ^g	Mo	Nb	Ni	Ti	V	Nb + Ti + V
		max.	max.		max.	max.	min.	max.	max.	max.	max.	max.	max.	max.	max.	max.
P275NH	1.0487					0,010										
P275NL1	1.0488	0,16	0,40	0,80 ^b to 1,50	0,025	0,008	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
P275NL2	1.1104				0,020	0,005										
P355N	1.0562															
P355NH	1.0565	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
P355NL1	1.0566					0,008										
P355NL2	1.1106				0,020	0,005										
P420NH	1.8932					0,010										
P420NL1	1.8912	0,20	0,60	1,10 to 1,70	0,025	0,008	0,020 ^{c,d}	0,020	0,30 ^e	0,30 ^e	0,10 ^e	0,05	0,80	0,03	0,20	0,22
P420NL2	1.8913				0,020	0,005										
P460NH	1.8935					0,010										
P460NL1	1.8915	0,20	0,60	1,10 to 1,70	0,025	0,008	0,020 ^{c,d}	0,025	0,30	0,70 ^f	0,10	0,05	0,80	0,03	0,20	0,22
P460NL2	1.8918				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 from scrap or other materials used in steelmaking of these elements which may adversely affect the mechanical properties and usability.

^b For nominal thicknesses <6 mm, a minimum Mn content of 0,60 % is permitted.

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

^d If only aluminium is used for nitrogen binding, a ratio $\frac{Al}{N} \geq 2$ 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.

^g A lower maximum copper content and/or a maximum sum of copper and tin content, e.g. Cu + Sn ≤ 0,33 %, may be agreed upon at the time of enquiry and order, e.g. with regard to hot formability.

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

^b For nominal thicknesses <6 mm, a minimum Mn content of 0,60 % is permitted.

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

^d If only aluminium is used for nitrogen binding, a ratio $\frac{Al}{N} \geq 2$ 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.

^g A lower maximum copper content and/or a maximum sum of copper and tin content, e.g. Cu + 6 Sn ≤ 0,33 %, may be agreed upon at the time of enquiry and order, e.g. with regard to hot formability.

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 grade		CEV ^b max. for nominal thicknesses t in mm		
Steel name	Steel number	$t \leq 60$	$60 < t \leq 100$	$100 < t \leq 250$
P275NH	1.0487	0,40	0,40	0,42
P275NL1	1.0488			
P275NL2	1.1104			
P355N	1.0562	0,43	0,45	0,45
P355NH	1.0565			
P355NL1	1.0566			
P355NL2	1.1106			
P420NH	1.8932	0,48	0,48	0,52
P420NL1	1.8912			
P420NL2	1.8913			
P460NH	1.8935	0,53	0,54	0,54
P460NL1	1.8915			
P460NL2	1.8918			

NOTE The values for the carbon equivalent are based on the percentage by mass and relate to the mechanical properties according to this document.

^a See 8.3.3.

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

Table A.3 — Tensile properties at room temperature

Steel grade		Nominal thickness t mm	Yield strength R_{eH} MPa min.	Tensile strength R_m MPa	Elongation after fracture A % min.
Steel name	Steel number				
P275NH P275NL1 P275NL2	1.0487	≤ 16	275	390 to 510	24
		$16 < t \leq 40$	265		
	1.0488	$40 < t \leq 60$	255	370 to 490	23
	1.1104	$60 < t \leq 100$	235		
		$100 < t \leq 150$	225		
		$150 < t \leq 250$	215		
P355N P355NH P355NL1 P355NL2	1.0562	≤ 16	355	490 to 630	22
		$16 < t \leq 40$	345		
	1.0565	$40 < t \leq 60$	335	470 to 610	21
	1.0566	$60 < t \leq 100$	315		
	1.1106	$100 < t \leq 150$	305		
		$150 < t \leq 250$	295		
P420NH, P420NL1 P420NL2	1.8932	≤ 16	420	540 to 690	19
		$16 < t \leq 40$	405		
	1.8912	$40 < t \leq 60$	395	515 to 665	
	1.8913	$60 < t \leq 100$	370		
		$100 < t \leq 150$	350		
		$150 < t \leq 250$	340		
P460NH P460NL1 P460NL2	1.8935	$\leq 16^a$	460	570 to 730	16
		$16^a < t \leq 40$	445	570 to 720	
	1.8915	$40 < t \leq 60$	430	540 to 710	
	1.8918	$60 < t \leq 100$	400		
		$100 < t \leq 150$	380		
		$150 < t \leq 250$	370		

^a In the case of P460NH and P460NL1, up to 20 mm nominal thickness, a minimum R_{eH} of 460 MPa and a R_m range of 630 MPa to 725 MPa may be agreed at the time of enquiry and order.

^a In the case of P460NH and P460NL1, up to 20 mm nominal thickness, a minimum R_{eH} of 460 MPa and a R_m range of 630 MPa to 725 MPa may be agreed at the time of enquiry and order.

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

Steel grade		Nominal thickness t	Minimum proof strength, $R_{p0,2}$ MPa at a temperature in °C of							
Steel name	Steel number	mm	50	100	150	200	250	300	350	400
P275NH	1.0487	≤ 16	266	250	232	213	195	179	166	156
		$16 < t \leq 40$	256	241	223	205	188	173	160	150
		$40 < t \leq 60$	247	232	215	197	181	166	154	145
		$60 < t \leq 100$	227	214	198	182	167	153	142	133
		$100 < t \leq 150$	218	205	190	174	160	147	136	128
		$150 < t \leq 250$	208	196	181	167	153	140	130	122
P355NH	1.0565	≤ 16	343	323	299	275	252	232	214	202
		$16 < t \leq 40$	334	314	291	267	245	225	208	196
		$40 < t \leq 60$	324	305	282	259	238	219	202	190
		$60 < t \leq 100$	305	287	265	244	224	206	190	179
		$100 < t \leq 150$	295	277	257	236	216	199	184	173
		$150 < t \leq 250$	285	268	249	228	209	192	178	167
P420NH	1.8932	≤ 16	406	382	354	325	298	274	254	238
		$16 < t \leq 40$	392	369	341	314	287	264	245	230
		$40 < t \leq 60$	382	359	333	306	280	258	239	224
		$60 < t \leq 100$	358	337	312	287	263	241	224	210
		$100 < t \leq 150$	339	319	295	271	248	228	212	199
		$150 < t \leq 250$	329	309	286	263	241	222	206	193
P460NH	1.8935	≤ 16	445	419	388	356	326	300	278	261
		$16 < t \leq 40$	430	405	375	345	316	290	269	253
		$40 < t \leq 60$	416	391	362	333	305	281	260	244
		$60 < t \leq 100$	387	364	337	310	284	261	242	227
		$100 < t \leq 150$	368	346	320	294	270	248	230	216
		$150 < t \leq 250$	358	337	312	287	263	241	224	210

^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).

Table A.5 — Minimum impact energy values^a

Steel grade	Nominal thickness mm	Impact energy, KV_2 J min.									
		transverse					longitudinal				
		at a temperature in °C of									
		-50	-40	-20	0	+20	-50	-40	-20	0	+20
P...N, P...NH	≤ 250	—	—	30 ^a	40	50	—	—	45	65	75
P...NL1		—	27 ^a	35 ^a	50	60	30 ^a	40	50	70	80
P...NL2		27 ^a	30 ^a	40	60	70	42	45	55	75	85

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

^a A minimum impact energy value of 40 J may be agreed 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**

STANDARDSISO.COM : Click to view the full PDF of ISO 9328-3:2018

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

Steel grade	% by massa														
	C	Si	Mn	P	S	Al _{total}	Cr	Cu	Mo	Nb	Ni	Ti	V	B	Others
	max.	max.		max.	max.	min ^c	max ^b	max ^b	max ^b	max ^b	max ^b	max ^b	max ^b		
PT400N, PT400NH	0,18 ^d	≤ 0,40	≤ 1,40	0,020	0,020	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,05	≤ 0,001 0	Cr + C + Mo + Ni: ≤ 1,00 ^b
PT400NL1	0,15	≤ 0,40	0,70 to 1,50	0,015	0,010	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,05	≤ 0,001 0	Cr + C + Mo + Ni: ≤ 1,00 ^b
PT440N, PT440NH	0,18 ^d	≤ 0,55	≤ 1,60	0,020	0,020	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,10	≤ 0,001 0	Cr + C + Mo + Ni: ≤ 1,00 ^b
PT440NL1	0,16	≤ 0,55	0,70 to 1,60	0,015	0,010	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,10	≤ 0,001 0	Cr + C + Mo + Ni: ≤ 1,00 ^b
PT490N, PT490NH	0,18 ^d	0,15 to 0,55	≤ 1,60	0,020	0,020	0,020	0,30	0,40	0,12	0,05	0,50	0,03	0,10	≤ 0,001 0	Cr + C + Mo + Ni: ≤ 1,00 ^b
PT520N, PT520NH	0,20	0,15 to 0,55	≤ 1,60	0,020	0,020	0,020	0,30	0,40	0,12	0,05	0,80	0,03	0,10	≤ 0,001 0	Cr + C + 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.															

^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 nominal thicknesses, <i>t</i> , in mm		
	≤ 50	50 < <i>t</i> ≤ 100	100 < <i>t</i> ≤ 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
^a See 6.3.3. ^b $CEV = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$			

Table B.3 — Tensile properties at room temperature^a

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