INTERNATIONAL STANDARD

ISO 9328-3

Second 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
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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 second edition, together with ISO 9328-6, cancels and replaces ISO 9328-4:1991, which has been technically revised and separated into two parts.

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*

NOTE 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.

Introduction

In comparison with its first edition (ISO 9328-4:1991), this part of ISO 9328 takes into consideration partly deviating and additional requirements, thus offering the possibility of specifying products in accordance with European design codes and ASME type design codes.

Main further alterations are: specification of additional grades, partly decreased maximum phosphorus and sulfur contents, partly increased minimum impact values, information on processing, options for evaluation of resistance to hydrogen-induced cracking and for the step cooling test.

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

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 9328-1:2003, *Steel plates and strips for pressure purposes — Technical delivery conditions — Part 1: General requirements*

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

3 Terms and definitions

For the purpose 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, the grades P275NH, P275NL1, P355N, P355NH, P355NL1, PT400N, PT400NH, PT400NL1, PT440N, PT440NH, PT440NL1, PT490N and PT490NH are non-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 is specified in this part of ISO 9328. These are listed below under a) to n). 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) application of the $R_{p0,2}$ values of Table A.4 for the corresponding P...NL2 grade (see 6.4.2);

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

g) mid-thickness test pieces for the impact test (see Clause 8);

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

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

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

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

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

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

n) 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 N/mm^2, 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 9328-1:2003). In this case, tests on simulated normalized samples with an agreed frequency of testing may be agreed upon at the time of enquiry and order, to verify that the specified properties are complied with.

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 Testing in a simulated heat-treated condition does 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 analysis.

6.3.2 The product analysis may deviate from the specified values of the cast 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 analysis

Element	Specified limit of the cast analysis according to Tables A.1 and B.1 % by mass	Permissible deviation[a] of the product analysis % by mass
C	⩽ 0,20	+ 0,02
Si	⩽ 0,60	+ 0,06
Mn	⩽ 1,00	± 0,05
	> 1,00 to ⩽ 1,70	± 0,10
P	⩽ 0,030	+ 0,005
S	⩽ 0,015	+ 0,003
	> 0,015 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.

6.4 Mechanical properties

6.4.1 The values given in Tables A.3 to A.5 and B.3 and B.4 (see also ISO 9328-1 and clause 8) shall apply.

6.4.2 •• By agreement at the time of enquiry and order, the minimum proof stress $R_{p0,2}$ 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 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 may 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 and

t is the holding time in hours,

exceeds the critical P value of $P_{crit.} = 17{,}3$ (steel grades in accordance with Annex A) or, where regarded as necessary in the case of Annex B steel grades, the purchaser should, in his enquiry and order, inform the manufacturer accordingly and, where appropriate, tests on simulated post-weld heat-treated samples may be agreed upon 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, deviating from ISO 9328-1:2003, Table 3, footnote c, the preparation of 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 (steel grades in accordance with Annex A, but see 9.3) or on test pieces specified in the order (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 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	0,015	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															
P275NL2				0,020	0,010										
P355N	0,18	0,50	1,10 to 1,70	0,025	0,015	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															
P355NL2				0,020	0,010										
P460NH	0,20	0,60	1,10 to 1,70	0,025	0,015	0,020[d]	0,025	0,30	0,70[f]	0,10	0,05	0,80	0,03	0,20	0,22
P460NL1															
P460NL2				0,020	0,010										

[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 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} N/mm^2 min.	Tensile strength R_m N/mm^2	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	$\leqslant 16$	460	570 to 720 [c]	17
		$16 < t \leqslant 40$	445		
		$40 < t \leqslant 60$	430		
		$60 < t \leqslant 100$	400	540 to 710	
		$100 \leqslant t \leqslant 250$	[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 N/mm^2 is permitted.

[d] •• Values 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 $R_{p0,2}$ N/mm² 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
	$150 < t \leqslant 250$	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
	$100 < t \leqslant 250$	[b]	[b]	[b]	[b]	[b]	[b]	[b]	[b]

[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] •• 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 at a temperature in °C of					longitudinal[d] at a temperature in °C of				
		− 50	− 40	− 20	0	+ 20	− 50	− 40	− 20	0	+ 20
P355N, P...NH	$5^{b} \leqslant t \leqslant 250^{c}$	–	–	30	40	50	–	–	45	65	75
P…NL1		–	27	35	50	60	30	40	50	70	80
P...NL2		27	30	40	60	70	42	45	55	75	85

[a] See 6.2.1 to 6.2.4.

[b] See ISO 9328-1.

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

[d] The values apply for product thicknesses $\leqslant$ 40 mm.

Annex B
(normative)

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

Table B.1 — Chemical composition (cast 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 à 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[a]	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 analysis
(if agreed upon at the time of enquiry and order)[a]

Steel grade	CEV [b] % max. for product thicknesses, t, in mm		
	$\leqslant 50$	$50 < t \leqslant 100$	$100 < t \leqslant 150$
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] $\text{CEV} = \text{C} + \frac{\text{Mn}}{6} + \frac{\text{Cr} + \text{Mo} + \text{V}}{5} + \frac{\text{Ni} + \text{Cu}}{15}$

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

Steel grade	Usual delivery condition[b]	Product thickness t mm	Yield strength R_{eH} N/mm² min.	Tensile strength R_m N/mm²	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.