INTERNATIONAL STANDARD

ISO 9328-4

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

Part 4: Nickel-alloy steels with specified low temperature properties

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

Partie 4: Aciers alliés au nickel avec caractéristiques spécifiées à basse température

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 9328-4 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 9328-4:2004), 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 which shall be made at the time of enquiry and order. The clauses 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 4:
Nickel-alloy steels with specified low temperature properties

1 Scope

This part of ISO 9328 specifies the technical delivery conditions for plates and strip for pressure equipment made of nickel-alloy 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 This part of ISO 9328 offers the possibility of 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*

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

In accordance with ISO 4948-1 and ISO 4948-2, all steel grades covered by this part of ISO 9328 are alloyed special steels.

4.2 Designation

See ISO 9328-1.

NOTE 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.3, footnote b).

5.2 Options

A number of options are specified in this part of ISO 9328. These are listed below under a) to e). 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 that specified in Tables A.2, A.3, B.2 and B.3 (see 6.2.1);

b) special delivery condition for grades 14Ni9, 13Ni14+NT and 14Ni14 (see 6.2.3);

c) delivery of products in the untreated condition (see 6.2.4);

d) specification of an impact energy of 40 J (see Note to 6.4 and Table A.3);

e) impact test on longitudinal test pieces (see 9.3).

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 15NiMn6 as specified in ISO 9328-4, to be delivered with inspection document 3.1.B as specified in ISO 10474:1991 is designated as follows:

10 plates – 50 × 2 000 × 10 000 – ISO 9328-4 15NiMn6 – Inspection document 3.1.B

6 Requirements

6.1 Steelmaking process

See ISO 9328-1.

6.2 Delivery condition

6.2.1 •• Unless otherwise agreed upon at the time of enquiry and order, the products covered by this part of ISO 9328 shall be supplied in the usual conditions given in Tables A.2 and B.2 (see also 6.2.3 and 6.2.4).

NOTE Annex D gives heat treatment information for the purchaser for the steel grades of Annex A. Information on welding is provided in appropriate documents, e.g. EN 1011-1 and EN 1011-2 or IIS/IIW 382-71.

6.2.2 For steel grades 11MnNi5-3 and 13MnNi6-3 (see Annex A), normalizing may, at the discretion of the manufacturer, be replaced by normalizing rolling.

6.2.3 •• For steel grades 14Ni9, 13Ni14+NT and 14Ni14 (see Annex B), the delivery condition "thermomechanically rolled" may be agreed upon at the time of enquiry and order. In this case, the product shall be marked correspondingly (+M).

6.2.4 •• If so agreed at the time of enquiry and order, the products covered by this part of ISO 9328 may be supplied in the untreated condition.

6.2.5 For products delivered untreated, the specified tests shall be carried out on test pieces in the usual delivery condition given in Tables A.2 and B.2.

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 shall apply for the chemical composition according to the cast (heat) analysis.

6.3.2 The product analysis shall not deviate from the values for the cast (heat) analysis specified in Tables A.1 and B.1 by more than the values given in Table 1.

Table 1 — Permissible deviations of the product analysis from the specified limits for the cast (heat) analysis

Element	Maximum of specification range in the cast (heat) analysis % by mass	Permissible deviation[a] % by mass
C[b]	⩽ 0,18	+0,02
Si	⩽ 0,50	+0,05
Mn	⩽ 1,00	±0,05
	> 1,00 to ⩽ 1,70	±0,10
P[b]	⩽ 0,015	+0,003
	> 0,015 to ⩽ 0,025	+0,005
S[b]	⩽ 0,010	+0,003
	> 0,010 to ⩽ 0,020	+0,005
Al	⩾ 0,020	–0,005
Cr	⩽ 0,30	+0,05
Cu	⩽ 0,40	+0,05
Mo	⩽ 0,12	+0,03
Nb	⩽ 0,02	+0,01
Ni	⩽ 0,85	±0,05
	> 0,85 to ⩽ 3,75	±0,07
	> 3,75 to ⩽ 10,00	±0,10
Tl	⩽ 0,03	+0,01
V	⩽ 0,05	+0,01

[a] If several product analyses are carried out on one cast, and the contents of an individual element, as determined, lie outside the permissible range of the chemical composition specified for the cast (heat) analysis, then it is allowed either to exceed the permissible maximum value or to fall short of the permissible minimum value, but not both for one cast.

[b] In the case of 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

The values given in Tables A.2, A.3, B.2 and B.3 (see also ISO 9328-1) shall apply.

NOTE Optionally, for steel grades 11MnNi5-3, 13MnNi 6-3, 15NiMn6, 12Ni14 and X12Ni5, a minimum impact energy value of 40 J can be specified for temperatures where lower minimum values are specified (see Table A.3, footnote c).

6.5 Surface condition

See ISO 9328-1.

6.6 Internal soundness

See ISO 9328-1.

6.7 Dimensions and tolerances on dimensions

See ISO 9328-1.

6.8 Calculation of mass

See ISO 9328-1.

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.

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.

9.2 • Impact tests for verification of the impact energy values in Tables A.3 and B.3 shall be carried out on transverse test pieces (for steel grades in accordance with Annex A, but see 9.3) or on test pieces as specified in the order (for steel grades in accordance with Annex B; see Table B.3, footnote b).

9.3 •• For the impact test, verification of impact energy values 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.

NOTE For the grades 13Ni14, X8Ni9 and X9Ni9, the relevant heat treatment variant (+NT, +QT, +NT640, +QT640 or +QT680) belongs to the steel name.

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 grade	% by mass[a]							
	C max.	Si max.	Mn	P max.	S max.	Al_{total} min.	Ni	Other
11MnNi5-3	0,14	0,50	0,70 to 1,50	0,025	0,010	0,020	0,30[b] to 0,80	Nb ⩽ 0,05 V ⩽ 0,05
13MnNi6-3	0,16	0,50	0,85 to 1,70	0,025	0,010	0,020	0,30[b] to 0,80	Nb ⩽ 0,05 V ⩽ 0,05
15NiMn6	0,18	0,35	0,80 to 1,50	0,025	0,010	—	1,30 to 1,70	V ⩽ 0,05
12Ni14	0,15	0,35	0,30 to 0,80	0,020	0,005	—	3,25 to 3,75	V ⩽ 0,05
X12Ni5	0,15	0,35	0,30 to 0,80	0,020	0,005	—	4,75 to 5,25	V ⩽ 0,05
X8Ni9	0,10	0,35	0,30 to 0,80	0,020	0,005	—	8,50 to 10,00	Mo ⩽ 0,10 V ⩽ 0,05
X7Ni9	0,10	0,35	0,30 to 0,80	0,015	0,005	—	8,50 to 10,00	Mo ⩽ 0,10 V ⩽ 0,01

[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. The content of Cr + Cu + Mo shall not exceed 0,50 %.

[b] For product thicknesses ⩽ 40 mm, a minimum nickel content of 0,15 % is permitted.

Table A.2 — Mechanical properties at room temperature

Steel grade	Usual delivery condition[a,b]	Product thickness t mm	Yield strength R_{eH} MPa[d] min.	Tensile strength R_m MPa[d]	Elongation after fracture A % min.
11MnNi5-3	+N (+NT)[c]	$\leqslant 30$	285	420 to 530	24
		$30 < t \leqslant 50$	275		
		$50 < t \leqslant 80$	265		
13MnNi6-3	+N (+NT)[c]	$\leqslant 30$	355	490 to 610	22
		$30 < t \leqslant 50$	345		
		$50 < t \leqslant 80$	335		
15NiMn6	+N or +NT or +QT	$\leqslant 30$	355	490 to 640	22
		$30 < t \leqslant 50$	345		
		$50 < t \leqslant 80$	335		
12Ni14	+N or +NT or +QT	$\leqslant 30$	355	490 to 640	22
		$30 < t \leqslant 50$	345		
		$50 < t \leqslant 80$	335		
X12Ni5	+N or +NT or +QT	$\leqslant 30$	390	530 to 710	20
		$30 < t \leqslant 50$	380		
X8Ni9 +NT640[a]	+N plus +NT	$\leqslant 30$	490	640 to 840	18
		$30 < t \leqslant 50$	480		
X8Ni9 +QT640[a]	+QT	$\leqslant 30$	490		
		$30 < t \leqslant 50$	480		
X8Ni9 +QT680[a]	+QT[c]	$\leqslant 30$	585	680 to 820	18
		$30 < t \leqslant 50$	575		
X7Ni9	+QT[c]	$\leqslant 30$	585	680 to 820	18
		$30 < t \leqslant 50$	575		

a +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered; +NT640/+QT640/+QT680: heat treatment variant with minimum tensile strength of 640 MPa or 680 MPa. All grades may be delivered untreated by agreement, see 6.2.4.

b For temperatures and cooling conditions, see Table D.1.

c For product thicknesses < 15 mm, delivery conditions +N plus +NT are also applicable.

d 1 MPa = 1 N/mm^2.

Table A.3 — Minimum impact energy values (valid for V-notched test pieces)

Steel grade	Heat treatment condition[a,b]	Product thickness t mm	Direction	Minimum impact energy KV J at a temperature in °C of											
				20	0	−20	−40	−50	−60	−80	−100	−120	−150	−170	−196
11MnNi5-3 13MnNi6-3	+N (+NT)	⩽ 80	longitudinal	70	60	55	50	45	40	—	—	—	—	—	—
			transverse	50	50	45	35[c]	30[c]	27[c]	—	—	—	—	—	—
15NiMn6	+N or +NT or +QT		longitudinal	65	65	65	60	50	50	40	—	—	—	—	—
			transverse	50	50	45	40	35[c]	35[c]	27[c]	—	—	—	—	—
12Ni14	+N or +NT or +QT		longitudinal	65	60	55	55	50	50	45	40	—	—	—	—
			transverse	50	50	45	35[c]	35[c]	35[c]	30[c]	27[c]	—	—	—	—
X12Ni5	+N or +NT or +QT	⩽ 50	longitudinal	70	70	70	65	65	65	60	50	40[d]	—	—	—
			transverse	60	60	55	45	45	45	40	30[c]	27[c,d]	—	—	—
X8Ni9+NT640, X8Ni9+QT640	+N plus +NT; +QT		longitudinal	100	100	100	100	100	100	100	90	80	70	60	50
			transverse	70	70	70	70	70	70	70	60	50	50	45	40
X8Ni9+QT680	+QT		longitudinal	120	120	120	120	120	120	120	110	100	90	80	70
			transverse	100	100	100	100	100	100	100	90	80	70	60	50
X7Ni9	+QT		longitudinal	120	120	120	120	120	120	120	120	120	120	110	100
			transverse	100	100	100	100	100	100	100	100	100	100	90	80

[a] +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered; +NT640/+QT640/+QT680: heat treatment variant with minimum tensile strength of 640 MPa or 680 MPa.

[b] Other delivery conditions may be agreed (see 6.2.1).

[c] •• An impact energy value of 40 J may be agreed at the time of enquiry and order.

[d] The values are applicable for product thicknesses ⩽ 25 mm at −110 °C and for product thicknesses of 25 mm < t ⩽ 30 mm at −115 °C.

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 max.	P max.	S max.	Cr max.	Cu max.	Mo max.	Nb max.	Ni	Ti max.	V max.
14Ni9	0,17	0,30	0,70	0,025	0,020	0,30	0,40	0,12	0,02	2,10 to 2,50	0,03	0,05
13Ni14[b]	0,15	0,30	0,70	0,025	0,020	0,30	0,40	0,12	0,02	3,25 to 3,75	0,03	0,05
14Ni14	0,17	0,30	0,70	0,025	0,020	0,30	0,40	0,12	0,02	3,25 to 3,75	0,03	0,05
X9Ni5	0,13	0,30	0,70	0,025	0,020	0,30	0,40	0,12	0,02	4,75 to 6,00	0,03	0,05
X9Ni9[b]	0,12	0,30	0,90	0,025	0,020	0,30	0,40	0,12	0,02	8,50 to 9,50	0,03	0,05

[a] Elements not listed in this table shall not intentionally be 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] See Table B.2 for complete steel names.

Table B.2 — Mechanical 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.
14Ni9	+N,+NT[d]	$6 \leqslant t \leqslant 50$	255	450 to 590	21
13Ni14+NT	+N,+NT[d]	$6 \leqslant t \leqslant 50$	255	450 to 590	21
13Ni14+QT	+QT[e]	$6 \leqslant t \leqslant 50$	440	540 to 690	18
14Ni14	+N,+NT[d]	$6 \leqslant t \leqslant 50$	275	480 to 620	19
X9Ni5	+QT[e]	$6 \leqslant t \leqslant 50$	590	690 to 830	18
X9Ni9+NT	+N plus +NT[e]	$6 \leqslant t \leqslant 50$	520	690 to 830	18
X9Ni9+QT	+QT[e]	$6 \leqslant t \leqslant 100$	590	690 to 830	18

[a] Applicable for transverse direction.

[b] +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered.

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

[d] By agreement, thermomechanically rolled (+M) may be applied (see 6.2.3).

[e] An intermediate heat treatment, an operation of cooling from a dual phase composed of austenite and ferrite, intended for improving toughness, may be applied prior to tempering, if necessary.

Table B.3 — Minimum impact energy values (valid for V-notched test pieces)

Steel grade	Usual delivery condition[a]	Product thickness t mm	Impact energy[b] KV J at a temperature in °C of				
			−196	−130	−110	−101	−70
14Ni9	+N,+NT[c]	$6 \leqslant t \leqslant 50$					21
13Ni14+NT	+N,+NT[c]	$6 \leqslant t \leqslant 50$				21	
13Ni14+QT	+QT[d]	$6 \leqslant t \leqslant 50$			27		
14Ni14	+N,+NT[c]	$6 \leqslant t \leqslant 50$				21	
X9Ni5	+QT[d]	$6 \leqslant t \leqslant 50$		41			
X9Ni9+NT[e]	+N +NT[d]	$6 \leqslant t \leqslant 50$	34				
X9Ni9+QT[e]	+QT[d]	$6 \leqslant t \leqslant 100$	41				

[a] +N: normalized; +NT: normalized and tempered; +QT: quenched and tempered.

[b] For longitudinal or transverse test pieces, as specified at the time of enquiry and order (see 9.2).

[c] By agreement, special rolling or a corresponding heat treatment may be applied (see 6.2.3).

[d] An intermediate heat treatment, an operation of cooling from a dual phase composed of austenite and ferrite, intended for improving toughness, may be applied prior to tempering, if necessary.

[e] For steel grades X9Ni9, each test piece shall have a lateral expansion opposite the notch of not less than 0,381 mm.