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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

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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.

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 9328-4:2011), which has been technically revised. The following changes have been made:

— the term “product thickness” has been replaced with “nominal thickness”;

— the new steel grades X6Ni7 and X9Ni7 have been added;

— the example of ordering has been revised;

— additional steel grades have been included in Clause 11.

— in Table B.1, 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 4: Nickel-alloy steels with specified low temperature properties

1 Scope

This document 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 document.

NOTE This document offers the possibility of 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*

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

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

4.2 Designation

Shall be in accordance with 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

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.3, footnote [b]).

5.2 Options

A number of options are specified in this document. These are listed below under a) to f). 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) tests in the simulated normalized condition (see 6.2.2);

c) special delivery condition for grades 14Ni9, 13Ni14+NT, 14Ni14 and X9Ni7 (see 6.2.3);

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

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

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

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 15NiMn6 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 9328-4 15NiMn6 – 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 upon at the time of enquiry and order, the products covered by this document 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 (see 5.2, Option 2).

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 document may be supplied in the untreated condition.

The plates delivered in untreated conditions shall be appropriately marked (+AR) to denote that heat treatment has not been performed.

6.2.5 For products delivered untreated, the specified tests shall be carried out by the manufacturer 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

[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.

Table 1 *(continued)*

Element	Maximum of specification range in the cast (heat) analysis % by mass	Permissible deviation[a] % by mass
Ni	≤ 0,85	±0,05
	> 0,85 to ≤ 3,75	±0,07
	> 3,75 to ≤ 10,00	±0,10
TI	≤ 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

Shall be in accordance with ISO 9328-1.

6.6 Internal soundness

Shall be in accordance with ISO 9328-1.

6.7 Dimensions and tolerances on dimensions

Shall be in accordance with ISO 9328-1.

6.8 Calculation of mass

Shall be in accordance with ISO 9328-1.

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.

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.

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

Shall be in accordance with 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.

11 Handling

The steel grade X6Ni7, X7Ni9, X8Ni9, X9Ni5, X9Ni7, X9Ni9 and X12Ni5 are susceptible to magnetization. Use of magnets in handling after heat treatment should be avoided if residual magnetism would be detrimental to subsequent fabrication or service.

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
X6Ni7	0,10	0,30	0,30 to 0,80	0,015	0,005	—	6,5 to 8,0	Mo ≤ 0,30 V ≤ 0,01
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 nominal 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]	Nominal 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)	≤ 30	285	420 to 530	24
		30 < t ≤ 50	275		
		50 < t ≤ 80	265		

[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 nominal thicknesses < 15 mm, delivery conditions +N plus +NT are also applicable.

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

[e] An intermediate heat treatment after quenching and before tempering may be applied as an option.

Table A.2 *(continued)*

Steel grade	Usual delivery condition[a,b]	Nominal thickness t mm	Yield strength R_{eH} MPa[d] min.	Tensile strength R_m MPa[d]	Elongation after fracture A % min.
13MnNi6-3	+N (+NT)	≤ 30	355	490 to 610	22
		30 < t ≤ 50	345		
		50 < t ≤ 80	335		
15NiMn6	+N or +NT or +QT	≤ 30	355	490 to 640	22
		30 < t ≤ 50	345		
		50 < t ≤ 80	335		
12Ni14	+N or +NT or +QT	≤ 30	355	490 to 640	22
		30 < t ≤ 50	345		
		50 < t ≤ 80	335		
X12Ni5	+N or +NT or +QT	≤ 30	390	530 to 710	20
		30 < t ≤ 50	380		
X8Ni9 +NT640[a]	+N plus +NT	≤ 30	490	640 to 840	18
		30 < t ≤ 50	480		
X8Ni9 +QT640[a]	+QT	≤ 30	490		
		30 < t ≤ 50	480		
X8Ni9 +QT680[a]	+QT[c]	≤ 30	585	680 to 820	18
		30 < t ≤ 50	575		
X6Ni7	QT or QQT[e]	≤ 40	585	680 to 825	18
X7Ni9	+QT[c]	≤ 30	585	680 to 820	18
		30 < t ≤ 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 nominal thicknesses < 15 mm, delivery conditions +N plus +NT are also applicable.

[d] 1 MPa = 1 N/mm².

[e] An intermediate heat treatment after quenching and before tempering may be applied as an option.

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

Steel grade	Heat treatment condition[a,b]	Nominal 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	≤ 50	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	≤ 50	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
X6Ni7	QT or QQT[e]	≤ 40	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
X7Ni9	+QT	≤ 50	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 nominal thicknesses ≤ 25 mm at −110 °C and for nominal thicknesses of 25 mm < t ≤ 30 mm at −115 °C.

[e] An intermediate heat treatment after quenching and before tempering may be applied as an option.

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	0,015	0,015	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	0,015	0,015	0,30	0,40	0,12	0,02	3,25 to 3,75	0,03	0,05
14Ni14	0,17	0,30	0,70	0,015	0,015	0,30	0,40	0,12	0,02	3,25 to 3,75	0,03	0,05
X9Ni5	0,13	0,30	0,70	0,015	0,015	0,30	0,40	0,12	0,02	4,75 to 6,00	0,03	0,05
X9Ni7	0,12	0,30	1,20	0,015	0,015	0,30	0,40	0,12	0,02	6,00 to 7,50	0,03	0,05
X9Ni9[b]	0,12	0,30	0,90	0,015	0,015	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]	$6 \leq t \leq 50$	255	450 to 590	21
13Ni14+NT	+N,+NT[d]	$6 \leq t \leq 50$	255	450 to 590	21
13Ni14+QT	+QT[e]	$6 \leq t \leq 50$	440	540 to 690	18
14Ni14	+N,+NT[d]	$6 \leq t \leq 50$	275	480 to 620	19
X9Ni5	+QT[e]	$6 \leq t \leq 50$	590	690 to 830	18
X9Ni7	+M	$6 \leq t \leq 50$	520	690 to 830	18
X9Ni9+NT	+N plus +NT[e]	$6 \leq t \leq 50$	520	690 to 830	18
X9Ni9+QT	+QT[e]	$6 \leq t \leq 100$	590	690 to 830	18

[a] Applicable for transverse direction.

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

[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]	$6 \leq t \leq 50$	—	—	—	—	21
13Ni14+NT	+N,+NT[c]	$6 \leq t \leq 50$	—	—	—	21	—
13Ni14+QT	+QT[d]	$6 \leq t \leq 50$	—	—	27	—	—
14Ni14	+N,+NT[c]	$6 \leq t \leq 50$	—	—	—	21	—
X9Ni5	+QT[d]	$6 \leq t \leq 50$	—	41	—	—	—
X9Ni7	+M	$6 \leq t \leq 60$	41	—	—	—	—
X9Ni9+NT[e]	+N +NT[d]	$6 \leq t \leq 50$	34	—	—	—	—
X9Ni9+QT[e]	+QT[d]	$6 \leq t \leq 100$	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.