

# Flat products made of steels for pressure purposes

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

ICS 77.140.30; 77.140.50

## National foreword

This British Standard is the UK implementation of EN 10028-4:2009. It supersedes BS EN 10028-4:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/73/2, Steel plates and bars for pressure purposes.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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**Flat products made of steels for pressure purposes - Part 4:  
Nickel alloy steels with specified low temperature properties**

Produits plats en aciers pour appareils à pression - Partie  
4: Aciers alliés au nickel avec caractéristiques spécifiées à  
basse température

Flacherzeugnisse aus Druckbehälterstählen - Teil 4:  
Nickellegierte kaltzähe Stähle

This European Standard was approved by CEN on 14 May 2009.

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## Foreword

This document (EN 10028-4:2009) has been prepared by Technical Committee ECISS/TC 22 "Steels for pressure purposes - Qualities", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2009, and conflicting national standards shall be withdrawn at the latest by December 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 10028-4:2003.

This European Standard consists of the following parts, under the general title *Flat products made of steels for pressure purposes*:

- *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 by two points (●●) contain information relating to agreements that may be made at the time of enquiry and order.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 97/23/EC.

For relationship with EU Directive 97/23/EC, see informative Annex ZA, which is an integral part of this document.

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## **1 Scope**

This European Standard specifies requirements for flat products for pressure equipment made of nickel alloy steels as specified in Table 1.

The requirements and definitions of EN 10028-1:2007 + A1:2009 also apply.

**NOTE** Once this European Standard is published in the EU Official Journal (OJEU) under Directive 97/23/EC, presumption of conformity to the Essential Safety Requirements (ESRs) of Directive 97/23/EC is limited to technical data of materials in this European Standard (Part 1 and this Part 4 of the series) and does not presume adequacy of the material to a specific item of equipment. Consequently, the assessment of the technical data stated in this material standard against the design requirements of this specific item of equipment to verify that the ESRs of Directive 97/23/EC are satisfied, needs to be done.

## **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.

EN 10028-1:2007 + A1:2009, *Flat products made of steels for pressure purposes – Part 1: General requirements*

EN 10204:2004, *Metallic products – Types of inspection documents*

## **3 Terms and definitions**

For the purposes of this document, the terms and definitions given in EN 10028-1:2007 + A1:2009 apply.

## **4 Dimensions and tolerances on dimensions**

See EN 10028-1:2007 + A1:2009.

## **5 Calculation of mass**

See EN 10028-1:2007 + A1:2009,

## **6 Classification and designation**

### **6.1 Classification**

In accordance with EN 10020, all steel grades covered by this document are alloy special steels.

### **6.2 Designation**

See EN 10028-1:2007 + A1:2009.

## **7 Information to be supplied by the purchaser**

### **7.1 Mandatory information**

See EN 10028-1:2007 + A1:2009.

## 7.2 Options

A number of options are specified in this European Standard and listed below. Additionally the relevant options of EN 10028-1:2007 + A1:2009 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 also EN 10028-1:2007 + A1:2009).

- 1) delivery condition other than that specified in Table 3 (see 8.2.2);
- 2) delivery of products in the untreated condition (see 8.2.3);
- 3) specification of a minimum impact energy of 40 J (see NOTE to 8.4 and Table 4);
- 4) mid thickness test pieces for the impact test (see Clause 10);
- 5) verification of impact energy for longitudinal test pieces (see Clause 11).

## 7.3 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 and the number 1.6228 as specified in EN 10028-4, to be delivered with inspection document 3.1 as specified in EN 10204.

**10 plates – 50 x 2000 x 10 000 – EN 10028-4 15NiMn6 – Inspection document 3.1**

or

**10 plates – 50 x 2000 x 10 000 – EN 10028-4 1.6228 – Inspection document 3.1.**

## 8 Requirements

### 8.1 Steelmaking process

See EN 10028-1:2007 + A1:2009.

### 8.2 Delivery condition

**8.2.1** The delivery condition shall be noted in the inspection document.

**8.2.2** •• Unless otherwise agreed at the time of enquiry and order, the products covered by this document shall be supplied in the usual delivery conditions specified in Table 3.

**8.2.3** •• If so agreed at the time of enquiry and order, the products may be supplied in the untreated condition.

In these cases, the specified tests shall be carried out on test pieces in the usual delivery condition as given in Table 3.

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.

### 8.3 Chemical composition

**8.3.1** The requirements of Table 1 shall apply for the chemical composition according to the cast analysis.

**8.3.2** The product analysis shall not deviate from the specified values for the cast analysis as specified in Table 1 by more than the values given in Table 2.

**Table 1 — Chemical composition (cast analysis) <sup>a</sup>**

Steel grade		% by mass									
Steel name	Steel number	C max.	Si max.	Mn	P max.	S max.	Al <sub>total</sub> min.	Mo max.	Nb max.	Ni	V max.
11MnNi5-3	1.6212	0,14	0,50	0,70 to 1,50	0,025	0,010	0,020	–	0,05	0,30 <sup>b</sup> to 0,80	0,05
13MnNi6-3	1.6217	0,16	0,50	0,85 to 1,70	0,025	0,010	0,020	–	0,05	0,30 <sup>b</sup> to 0,85	0,05
15NiMn6	1.6228	0,18	0,35	0,80 to 1,50	0,025	0,010	–	–	–	1,30 to 1,70	0,05
12Ni14	1.5637	0,15	0,35	0,30 to 0,80	0,020	0,005	–	–	–	3,25 to 3,75	0,05
X12Ni5	1.5680	0,15	0,35	0,30 to 0,80	0,020	0,005	–	–	–	4,75 to 5,25	0,05
X8Ni9	1.5662	0,10	0,35	0,30 to 0,80	0,020	0,005	–	0,10	–	8,5 to 10,0	0,05
X7Ni9	1.5663	0,10	0,35	0,30 to 0,80	0,015	0,005	–	0,10	–	8,5 to 10,0	0,01

<sup>a</sup> 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. The content of Cr + Cu + Mo shall not exceed 0,50 %.

<sup>b</sup> For product thicknesses ≤ 40 mm, a minimum nickel content of 0,15 % is permitted.

**Table 2 — Permissible product analysis tolerances on the limiting values given in Table 1 for the cast analysis**

Element	Specified value in the cast analysis according to Table 1	Permissible deviation <sup>a</sup> of the product analysis
	% by mass	% by mass
C	≤ 0,18	+ 0,02
Si	≤ 0,50	+ 0,05
Mn	≤ 1,00	± 0,05
	> 1,00 to ≤ 1,70	± 0,10
P	≤ 0,015	+ 0,003
	> 0,015 to ≤ 0,025	+ 0,005
S	≤ 0,010	+ 0,003
Al	≥ 0,020	- 0,005
Mo	≤ 0,10	+ 0,03
Nb	≤ 0,05	+ 0,01
Ni	≤ 0,85	± 0,05
	> 0,85 to ≤ 3,75	± 0,07
	> 3,75 to ≤ 10,0	± 0,10
V	≤ 0,05	+ 0,01

<sup>a</sup> If several product analyses are carried out on one cast, and the contents of an individual element determined lie outside the permission 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.

## 8.4 Mechanical properties

The values given in Tables 3 and 4 (see also EN 10028-1:2007 + A1:2009 and clause 10) shall apply.

NOTE Optionally, for steel grades 11MnNi5-3, 13MnNi6-3, 15NiMn6, 12Ni14 and X12Ni5, a minimum impact energy value of 40 J may be specified for temperatures where lower minimum values are specified (see Table 4, footnote d).



**Table 3 — Mechanical properties at room temperature**

Steel grade		Usual delivery condition <sup>a,b</sup> (Heat treatment symbol)	Product thickness <i>t</i>  mm	Yield strength  <i>R<sub>eH</sub></i>  MPa min.	Tensile strength  <i>R<sub>m</sub></i>  MPa	Elongation after fracture <i>A</i>  % min.
Steel name	Steel number					
11MnNi5-3	1.6212	+N (+NT)	≤ 30	285	420 to 530	24
			30 < <i>t</i> ≤ 50	275		
			50 < <i>t</i> ≤ 80	265		
13MnNi6-3	1.6217	+N (+NT)	≤ 30	355	490 to 610	22
			30 < <i>t</i> ≤ 50	345		
			50 < <i>t</i> ≤ 80	335		
15NiMn6	1.6228	+N or +NT or +QT	≤ 30	355	490 to 640	22
			30 < <i>t</i> ≤ 50	345		
			50 < <i>t</i> ≤ 80	335		
12Ni14	1.5637	+N or +NT or +QT	≤ 30	355	490 to 640	22
			30 < <i>t</i> ≤ 50	345		
			50 < <i>t</i> ≤ 80	335		
X12Ni5	1.5680	+N or +NT or +QT	≤ 30	390	530 to 710	20
			30 < <i>t</i> ≤ 50	380		
X8Ni9 +NT640 <sup>a</sup>	1.5662 +NT640 <sup>a</sup>	+N plus +NT	≤ 30	490	640 to 840	18
			30 < <i>t</i> ≤ 50	480		
X8Ni9 +QT640 <sup>a</sup>	1.5662 +QT640 <sup>a</sup>	+QT	≤ 30	490		
			30 < <i>t</i> ≤ 50	480		
X8Ni9 +QT680 <sup>a</sup>	1.5662 +QT680 <sup>a</sup>	+QT <sup>c</sup>	≤ 30	585	680 to 820	18
			30 < <i>t</i> ≤ 50	575		
X7Ni9	1.5663	+QT <sup>c</sup>	≤ 30	585	680 to 820	18
			30 < <i>t</i> ≤ 50	575		

<sup>a</sup> +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.  
<sup>b</sup> For temperatures and cooling conditions, see Table A.1.  
<sup>c</sup> For product thickness < 15 mm, delivery conditions +N plus +NT are also applicable.

Table 4 — Minimum impact energy values

Steel grade		Heat treatment condition <sup>a,b</sup>	Product thickness mm	Direction	Minimum impact energy $K_{I\prime}$ in J											
Steel name	Steel number				at a temperature in °C of											
				20	0	-20	-40	-50	-60	-80	-100	-120	-150	-170	-196	
11MnNi5-3	1.6212	+N (+NT)	≤ 80	longitudinal	70	60	55	50	45	40	–	–	–	–	–	
13MnNi6-3	1.6217			transverse	50	50	45	35 <sup>d</sup>	30 <sup>d</sup>	27 <sup>d</sup>	–	–	–	–	–	–
15NiMn6	1.6228	+N or +NT or +QT		longitudinal	65	65	65	60	50	50	40	–	–	–	–	–
				transverse	50	50	45	40	35 <sup>d</sup>	35 <sup>d</sup>	27 <sup>d</sup>	–	–	–	–	–
12Ni14	1.5637	+N or +NT or +QT		longitudinal	65	60	55	55	50	50	45	40	–	–	–	–
				transverse	50	50	45	35 <sup>d</sup>	35 <sup>d</sup>	35 <sup>d</sup>	30 <sup>d</sup>	27 <sup>d</sup>	–	–	–	–
X12Ni5	1.5680	+N or +NT or +QT	longitudinal	70	70	70	65	65	65	60	50	40 <sup>c</sup>	–	–	–	
			transverse	60	60	55	45	45	45	40	30 <sup>d</sup>	27 <sup>c,d</sup>	–	–	–	
X8Ni9+NT640; X8Ni9+QT640 <sup>a</sup>	1.5662+NT640; 1.5662+QT640 <sup>a</sup>	+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 <sup>a</sup>	1.5662 +QT680 <sup>a</sup>	+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	1.5663	+QT	longitudinal	120	120	120	120	120	120	120	120	120	120	120	110	100
			transverse	100	100	100	100	100	100	100	100	100	100	100	90	80

<sup>a</sup> +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.  
<sup>b</sup> For temperatures and cooling conditions, see Table A.1.  
<sup>c</sup> 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.  
<sup>d</sup> ●● A minimum impact energy value of 40 J may be agreed at the time of enquiry and order.

## 8.5 Surface condition

See EN 10028-1:2007 + A1:2009.

## 8.6 Internal soundness

See EN 10028-1:2007 + A1:2009.

For possible verification of internal soundness, see also EN 10028-1:2007 + A1:2009.

## 9 Inspection

### 9.1 Types of inspection and inspection documents

See EN 10028-1:2007 + A1:2009.

### 9.2 Tests to be carried out

See EN 10028-1:2007 + A1:2009.

### 9.3 Retests

See EN 10028-1:2007 + A1:2009.

## 10 Sampling

See EN 10028-1:2007 + A1:2009.

•• For the impact test, deviating from EN 10028-1:2007 + A1:2009, Table 3, footnote f, the preparation of test pieces taken from the mid thickness may be agreed at the time of enquiry and order. In this case, test temperatures and minimum impact energy values shall also be agreed.

## 11 Test methods

See EN 10028-1:2007 + A1:2009.

•• For the impact test, verification of impact energy for longitudinal test pieces may be agreed at the time of enquiry and order in accordance with 10.2.2.3 and 11.4 in EN 10028-1:2007 + A1:2009.

## 12 Marking

See EN 10028-1:2007 + A1:2009.

NOTE For the grade X8Ni9 the relevant heat treatment variant (+NT640 or +QT640 or +QT680) belongs to the steel name or steel number.

## Annex A (informative)

### Guidelines for heat treatment

Reference data on heat treatment temperatures and cooling media are given in Table A.1.

**Table A.1 — Guidelines on the temperatures and cooling media of heat treatment**

Steel grade		Heat treatment condition <sup>a</sup>	Heat treatment			
Steel name	Steel number		Austenitizing °C	Cooling <sup>b</sup>	Tempering °C	Cooling <sup>b</sup>
11MnNi5-3	1.6212	+N (+NT)	880 to 940	a	580 to 640	a
13MnNi6-3	1.6217	+N (+NT)	880 to 940	a	580 to 640	a
15NiMn6	1.6228	+N	850 to 900	a	-	-
		+NT	850 to 900	a	600 to 660	a or w
		+QT	850 to 900	w or o	600 to 660	a or w
12Ni14	1.5637	+N	830 to 880	a	-	-
		+NT	830 to 880	a	580 to 640	a or w
		+QT	820 to 870	w or o	580 to 640	a or w
X12Ni5	1.5680	+N	800 to 850	a	-	-
		+NT	800 to 850	a	580 to 660	a or w
		+QT	800 to 850	w or o	580 to 660	a or w
X8Ni9 +NT640	1.5662 +NT640	+N plus +NT	880 to 930 + 770 to 830	a	540 to 600	a or w
X8Ni9 +QT640	1.5662 +QT640	+QT	770 to 830	w or o	540 to 600	a or w
X8Ni9 +QT680	1.5662 +QT680	+QT <sup>c</sup>	770 to 830	w or o	540 to 600	a or w
X7Ni9	1.5663	+QT <sup>c</sup>	770 to 830	w or o	540 to 600	a or w

<sup>a</sup> +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.

<sup>b</sup> a: air; o: oil; w: water.

<sup>c</sup> See Table 3, footnote c.

## Annex ZA (informative)

### Relationship between this European Standard and the Essential Requirements of EU Directive 97/23/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the New Approach Directive 97/23/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

**Table ZA.1 — Correspondence between this European Standard and the Essential Requirements of EU Directive 97/23/EC, Annex I**

Clauses/sub-clauses of this European Standard	Essential Requirements (ERs) of Directive 97/23/EC, Annex I	Qualifying remarks/ Notes
8.4	4.1a	Appropriate material properties
8.2	4.1c	Ageing
8.2 and 8.6	4.1d	Suitable for the processing procedures
9.1	4.3	Documentation

**WARNING:** Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

## Bibliography

- [1] EN 10020, *Definition and classification of grades of steel*



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