BRITISH STANDARD

BS EN 10213:2007

Steel castings for pressure purposes

The European Standard EN 10213:2007 has the status of a British Standard

ICS 77.140.30

National foreword

This British Standard is the UK implementation of EN 10213:2007. It supersedes BS EN 10213-1:1996, BS EN 10213-2:1996, BS EN 10213-3:1996 and BS EN 10213-4:1996, which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee ISE/6, Steel castings.

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.

Compliance with a British Standard cannot confer immunity from legal obligations.

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English Version

Steel castings for pressure purposes

Pièces moulées en acier pour service sous pression

Stahlguss für Druckbehälter

This European Standard was approved by CEN on 30 September 2007.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 10213:2007) has been prepared by Technical Committee ECISS/TC 31 “Steel castings”, the secretariat of which is held by AFNOR.

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of an identical text or by endorsement, at the latest by May 2008, and conflicting national standards shall be withdrawn at the latest by May 2008.

This document supersedes EN 10213-1:1995, EN 10213-2:1995, EN 10213-3:1995 and EN 10213-4:1995.

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(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

EN 10213, *Technical delivery conditions for steel castings for pressure purposes* is a revision of the European Standard, EN 10213:1995, in four parts:

— *Part 1: General*

— *Part 2: Steel grades for use at room temperature and elevated temperatures*

— *Part 3: Steel grades for use at low temperatures*

— *Part 4: Austenitic and austenitic-ferritic steel grades*

The revision consists of:

— merging of the four previous parts and new arrangement of steel grades in tables;

— GP240GR has been deleted;

— GX10NiCrSiNb32-20 has been added.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This European Standard retains the same format for clauses as EN 1559-2:2000. This European Standard needs to be used in conjunction with EN 1559-2:2000. Where no text is given under a clause heading, the corresponding clause of EN 1559-2:2000 applies.

The structure of this European Standard is as follows:

— clauses and subclauses preceded by ■ indicates no additional conditions to EN 1559-2;

— subclauses and paragraphs marked with a single dot ● indicate that the conditions shall be agreed at the time of enquiry and order;

— subclauses marked with two dots ●● indicate that conditions may be agreed at the time of enquiry and order (optional);

— subclauses without dot marking are mandatory.

1 Scope

This European Standard applies to steel castings for pressure containing parts. It includes materials which are used for the manufacture of components, for pressure equipment.

This European Standard relates to castings characterised by their chemical composition (see Table 2) and mechanical properties (see Tables 3 to 6).

In cases where castings are joined by welding by the founder, this European Standard applies.

In cases where castings are welded:

— to wrought products (plates, tubes, forgings), or

— by non founders,

this European Standard does not apply.

NOTE For this harmonised supporting standard for materials, presumption of conformity to the Essential Requirements of the Directive is limited to technical data of the material in the standard and does not presume adequacy of the material to specific equipment. Consequently the technical data stated in the material standard should be assessed against the design requirements of the specific equipment to verify that the Essential Requirements of the Pressure Equipment Directive (PED) are satisfied.

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 287-1:2004, *Qualification test of welders — Fusion welding — Part 1: Steels*

EN 444:1994, *Non-destructive testing — General principles for radiographic examination of metallic materials by X- and gamma-rays*

EN 462-1:1994, *Non-destructive testing — Image quality of radiographs — Part 1: Image quality indicators (wire type) — Determination of image quality value*

EN 571-1:1997, *Non destructive testing — Penetrant testing — Part 1: General principles*

EN 583-1:1998, *Non-destructive testing — Ultrasonic examination — Part 1: General principles*

EN 1369:1996, *Founding — Magnetic particle inspection*

EN 1371-1:1997, *Founding — Liquid penetrant inspection — Part 1: Sand, gravity die and low pressure die castings*

EN 1371-2:1998, *Founding — Liquid penetrant inspection — Part 2: Investment castings*

EN 1559-2:2000, *Founding — Technical conditions of delivery — Part 2: Additional requirements for steel castings*

EN 10027-1:2005, *Designation system for steels — Part 1: Steel names*

EN 10027-2:1992, *Designation system for steels — Part 2: Numerical system*

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

EN 12454:1998, *Founding — Visual examination of surface discontinuities — Steel sand castings*

EN 12680-1:2003, *Founding — Ultrasonic examination — Part 1: Steel castings for general purposes*

EN 12680-2:2003, *Founding - Ultrasonic examination - Part 2: Steel castings for highly stressed components*

EN 12681:2003, *Founding — Radiographic examination*

EN ISO 3651-2:1998, *Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid (ISO 3651-2:1998)*

EN ISO 9934-1:2001, *Non-destructive testing — Magnetic particle testing — Part 1: General principles (ISO 9934-1:2001)*

EN ISO 11970:2007, *Specification and approval of welding procedures for production welding of steel castings (ISO 11970:2001)*

■ 3 Terms and definitions

4 Information to be supplied by the purchaser

● 4.1 Mandatory information

The relevant (ruling) wall thickness shall be agreed.

In cases of grades with different mechanical properties relating to heat treatment conditions, the purchaser shall specify the heat treatment symbol (see Clause 5).

■ 4.2 Optional information

5 Designation

In addition to EN 1559-2:2000:

Cast steels shall be designated in accordance with EN 10027-1 and EN 10027-2:

— either by their minimum yield strength (tensile test) for non alloy steels (preceded by letter P related to pressure uses);

— or by their chemical composition for alloy steels.

In cases of grades with different mechanical properties relating to heat treatment conditions, the purchaser shall specify the heat treatment symbol. For example: GX8CrNi12 + QT1 or GP280GH + N.

6 Manufacture

6.1 Manufacturing process

6.1.1 Melting

In addition to EN 1559-2:2000:

— alternative processes are left to the discretion of the manufacturer.

6.1.2 Heat treatment

6.1.2.1 Unless otherwise agreed, the type of heat treatment represented by its symbol shall comply with Table 3.

■ **6.1.2.2**

6.2 Welding operations

6.2.1 General

Unless otherwise agreed welding is permitted, provided that all welds shall conform to the same criteria for non-destructive testing as the relevant part of the casting. A welding procedure qualification is required (it may include prior agreement for major welds, weld maps…) according to EN ISO 11970.

6.2.2 Production welding

Conditions for preheat, interpass and postweld heat-treatment related to welding operations are given in Annex A. These conditions are informative for ferritic and martensitic grades, and are normative for austenitic and austenitic-ferritic grades.

The heat treatment procedure established to qualify the weld procedure for the austenitic and austenitic-ferritic steels is mandatory.

6.2.3 Permanent joint welding

The welding personnel for permanent joining of components shall be qualified according to EN 287-1.

■ 6.3 Further processing

7 Requirements

■ 7.1 General

7.2 Materials

7.2.1 Chemical composition

In addition to EN 1559-2:2000:

— chemical composition determined by a cast analysis shall conform with the values given in Table 2;

— elements unspecified shall not be intentionally added without agreement of the purchaser other than for the purpose of finishing the heat;

— permissible deviations between the specified cast analysis and the check analysis on test blocks are indicated EN 1559-2:2000;

●● a maximum carbon equivalent value (CEV) of 0,45 % for the cast analysis may be agreed at the time of enquiry and order for grades GP280GH (1.0625) and G20Mn5 (1.6220). The carbon equivalent value shall be calculated according to the following formula:

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

7.2.2 Mechanical properties

7.2.2.1 The mechanical properties at room temperature shall conform to the values given in Table 3.

The mechanical properties at low temperature for impact testing:

— shall conform to the values given in Table 4 for ferritic and martensitic grades;

— ●● may be agreed to the values given in Table 5 for austenitic and austenitic-ferritic grades.

They are verified on test blocks. In all cases the maximum thickness shall be limited to 150 mm.

● In cases where the ruling thickness specified by the purchaser is above the maximum thickness given in Table 3, the mechanical properties shall be agreed.

7.2.2.2 Proof strength at elevated temperatures shall conform to the values given in Table 6.

●● However, the verification is only made by agreement between the purchaser and the manufacturer at the time of enquiry and order.

7.2.2.3 The values of yield and tensile strength at room temperature also apply to the casting itself up to the maximum wall thickness as given in Table 3.

The yield strength values at room temperature correspond to:

— 0,2 % proof strength ($R_{p0,2}$) for ferritic, martensitic and austenitic-ferritic steels;

— 1,0 % proof strength ($R_{p1,0}$) for austenitic steels.

■ 7.2.3 Other properties

■ 7.3 Casting

■ 7.3.1 Chemical composition

■ 7.3.2 Mechanical properties

7.3.3 Non destructive testing

7.3.3.1 Requirements regarding the outer and/or inner conditions shall be agreed. They shall specify:

— method of non-destructive testing to be used;

— extent (area and/or frequency) of testing;

— acceptance criteria.

In those areas where non-destructive testing has been agreed, the required surface condition shall be ensured by the use of an appropriate process.

References to discontinuities shall be expressed in terms of dimension, quantity and location.

7.3.3.2 Where minor surface defects do not impair the application or if the surface of the casting corresponds to that of the initial sample, they need not be removed.

NOTE Examples of minor surface defects include small areas of sand or slag, small cold laps, small scabs, small shrink-holes, groups of small pores, residues of the moulding material, uneven areas, flash.

7.3.3.3 A conforming procedure for unacceptable external and internal discontinuities may be agreed between the purchaser and the manufacturer. In the case of as-cast castings, it is recommended that the purchaser discusses with the manufacturer the choice of any non-destructive testing and criteria to determine the acceptability of a subsequently machined surface. Unless specifically agreed, discontinuities revealed on the machined surface are not to be regarded as a non-conformity.

7.3.3.4 ●● If required, the surface condition including burrs and parting line flash shall be agreed upon.

NOTE Examples of acceptable surfaces include surface comparators or another casting used as a reference comparator etc.

7.3.3.5 Non destructive testing

In addition to EN 1559-2:2000:

● The castings shall be subjected to non destructive examination under conditions agreed at the time of enquiry and order.

— every order shall include information about:

— non destructive method involved (visual, magnetic particle, liquid penetrant, ultrasonic, radiographic …);

— severity levels for every method;

— areas of the casting to be tested (location and extent);

— percentage of castings to be inspected.

However, different acceptance criteria can be specified for different areas of the same casting (e.g. inner and outer zones). Moreover for the same area of the casting different acceptance criteria can be specified according to the non destructive methods selected.

The inspection shall be performed according to the relevant European Standard according to Table 1:

Table 1 — Inspection methods

Inspection method	Symbol	General principles	Inspection conditions
Visual	VT	No	EN 12454
Liquid penetrant	PT	EN 571-1	EN 1371-1, EN 1371-2
Magnetic particle	MT	EN ISO 9934-1	EN 1369
Ultrasonic	UT	EN 583-1	EN 12680-1, EN 12680-2
Radiographic	RT	EN 444, EN 462-1	EN 12681

■ 7.3.4 Condition of the casting

■ 7.3.5 Mass of the casting

■ 7.3.6 Additional requirements regarding the condition of the casting

●●7.4 Corrosion behaviour

Requirements for resistance to intergranular corrosion may be agreed between the manufacturer and the purchaser for austenitic and austenitic-ferritic grades according to EN ISO 3651-2.

8 Testing and documents on material testing

8.1 General

8.1.1 The manufacturer shall take the necessary measures to ensure compliance with the agreed requirements. The testing shall be carried out by competent persons.

8.1.2 ●● The purchaser may agree with the manufacturer suitable measures and levels of quality inspection, whether the inspectors have to be qualified and/or certificated, the requisite level of this certification and the extent of the documentation of test results.

When ordering material for pressure equipment applications, the equipment manufacturer has the obligation to request appropriate inspection documentation according to EN 10204:2004 affirming conformity to the specification for the material contained in this European Standard.

For all products ordered to the requirements of this European Standard, specific inspection and testing is required. This shall include the following:

— amounts of all elements specified (for the cast analysis) for the steel grade required;

— results of the mechanical tests as required for the specific steel grade in Tables 3 to 6, as applicable;

— statement on the result of agreed dimensional check and non destructive testing;

— ●● result of any further mutually agreed testing.

■ 8.2 Inspection and testing

8.3 Test unit sampling

Formation of test units

In addition to EN 1559-2:2000:

- In the case of castings under 1 000 kg in mass the delivered quantity shall be subdivided into lots covering castings of the same type from the same melt and having undergone the same heat treatment. The weight of a test lot shall be not greater than 5 000 kg.

- In the case of castings with a mass of more than 1 000 kg, each individual casting shall be regarded as the test lot.

■ 8.4 Samples (test blocks)

8.5 Test methods

■ a) Tensile test at room temperature;

■ b) ●● tensile test at elevated temperature, verification by agreement at the time of enquiry and order;

■ c) impact test;

■ d) ferrite content;

e) hardness test (not applicable);

■ f) homogeneity of test units (hardness test);

■ g) pressure or leak testing;

■ h) intergranular corrosion test (according to EN ISO 3651-2);

■ i) tests for magnetic properties;

■ j) other tests for any other properties shall be agreed.

■ 8.6 Invalidation of tests

■ 8.7 Retests

■ 8.8 Sorting and reprocessing

■ 9 Marking

■ 10 Packaging and surface protection

■ 11 Complaints

12 Supplementary information

Information on physical properties and creep properties of the steel grades are given in Annex B and Annex C.

Table 2 — Chemical composition (cast analysis) (% by mass)

	Designation		C	Si	Mn	P	S	Cr	Mo	Ni	Cu	N	V	Others
	Name	Number				Max.	max.							
Ferritic and martensitic	GP240GH	1.0619	0,18 to 0,23	0,60 max	0,50 to 1,20	0,030	0,020 [a]	0,30 [b] max.	0,12 [b] max.	0,40 [b] max.	0,30 max. [b]	-	0,03 [b] max	-
	GP280GH	1.0625	0,18 to 0,25 [c]	0,60 max	0,80 to 1,20 [c]	0,030	0,020 [a]	0,30 [b] max	0,12 [b] max.	0,40 [b] max.	0,30 [b] max.	-	0,03 [b] max	-
	G17Mn5	1.1131	0,15 to 0,20	0,60 max	1,00 to 1,60	0,020	0,020 [a]	0,30 [b] max.	0,12 [b] max.	0,40 [b] max.	0,30 max. [b]	-	0,03 [b] max.	-
	G20Mn5	1.6220	0,17 to 0,23	0,60 max	1,00 to 1,60	0,020	0,020 [a]	0,30 max.	0,12 max.	0,80 max.	0,30 max.	-	0,03 max.	-
	G18Mo5	1.5422	0,15 to 0,20	0,60 max	0,80 to 1,20	0,020	0,020	0,30 max.	0,45 to 0,65	0,40 max.	0,30 max.	-	0,05 max.	-
	G20Mo5	1.5419	0,15 to 0,23	0,60 max	0,50 to 1,00	0,025	0,020 [a]	0,30 max.	0,40 to 0,60	0,40 max.	0,30 max.	-	0,05 max.	-
	G17CrMo5-5	1.7357	0,15 to 0,20	0,60 max	0,50 to 1,00	0,020	0,020 [a]	1,00 to 1,50	0,45 to 0,65	0,40 max.	0,30 max.	-	0,05 max.	-
	G17CrMo9-10	1.7379	0,13 to 0,20	0,60 max	0,50 to 0,90	0,020	0,020 [a]	2,00 to 2,50	0,90 to 1,20	0,40 max.	0,30 max.	-	0,05 max.	-
	G12MoCrV5-2	1.7720	0,10 to 0,15	0,45 max.	0,40 to 0,70	0,030	0,020 [a]	0,30 to 0,50	0,40 to 0,60	0,40 max.	0,30 max.	-	0,22 to 0,30	Sn: 0,025 max.
	G17CrMoV5-10	1.7706	0,15 to 0,20	0,60 max.	0,50 to 0,90	0,020	0,015	1,20 to 1,50	0,90 to 1,10	0,40 max.	0,30 max.	-	0,20 to 0,30	Sn: 0,025 max.
	G9Ni10	1.5636	0,06 to 0,12	0,60 max.	0,50 to 0,80	0,020	0,015	0,30 max.	0,20 max.	2,00 to 3,00	0,30 max.	-	0,05 max.	-
	G17NiCrMo13-6	1.6781	0,15 to 0,19	0,50 max.	0,55 to 0,80	0,015	0,015	1,30 to 1,80	0,45 to 0,60	3,00 to 3,50	0,30 max.	-	0,05 max.	-
	G9Ni14	1.5638	0,06 to 0,12	0,60 max.	0,50 to 0,80	0,020	0,015	0,30 max.	0,20 max.	3,00 to 4,00	0,30 max.	-	0,05 max.	-
	GX15CrMo5	1.7365	0,12 to 0,19	0,80 max	0,50 to 0,80	0,025	0,025	4,00 to 6,00	0,45 to 0,65	-	0,30 max.	-	0,05 max.	-
	GX8CrNi12	1.4107	0,10 max.	0,40 max.	0,50 to 0,80	0,030	0,020	11,50 to 12,50	0,50 max.	0,80 to 1,50	0,30 max.	-	0,08 max.	-
	GX3CrNi13-4	1.6982	0,05 max.	1,00 max.	1,00 max.	0,035	0,015	12,00 to 13,50	0,70 max.	3,50 to 5,00	0,30 max.	-	0,08 max.	-
	GX4CrNi13-4	1.4317	0,06 max.	1,00 max.	1,00 max.	0,035	0,025	12,00 to 13,50	0,70 max.	3,50 to 5,00	0,30 max.	-	0,08 max.	-
	GX23CrMoV12-1	1.4931	0,20 to 0,26	0,40 max.	0,50 to 0,80	0,030	0,020	11,30 to 12,20	1,00 to 1,20	1,00 max.	0,30 max.	-	0,25 to 0,35	W: 0,50 max.
	GX4CrNiMo16-5-1	1.4405	0,06 max.	0,80 max.	1,00 max.	0,035	0,025	15,00 to 17,00	0,70 to 1,50	4,00 to 6,00	0,30 max.	-	0,08 max.	-

"to be continued"

Table 2 (*concluded*)

	Designation		C	Si	Mn	P	S	Cr	Mo	Ni	Cu	N	V	Others
	Name	Number				Max.	max.							
Austenitic and austenitic-ferritic	GX2CrNi19-11	1.4309	0,030 max.	1,50 max.	2,00 max.	0,035	0,025	18,00 to 20,00	-	9,00 to 12,00	0,50 max.	0,20 max.	-	-
	GX5CrNi19-10	1.4308	0,07 max.	1,50 max.	1,50 max.	0,040	0,030	18,00 to 20,00	-	8,00 to 11,00	0,50 max.	-	-	-
	GX5CrNiNb19-11	1.4552	0,07 max.	1,50 max.	1,50 max.	0,040	0,030	18,00 to 20,00	-	9,00 to 12,00	0,50 max.	-	-	Nb [d]
	GX2CrNiMo19-11-2	1.4409	0,030 max.	1,50 max.	2,00 max.	0,035	0,025	18,00 to 20,00	2,00 to 2,50	9,00 to 12,00	0,50 max.	0,20 max.	-	-
	GX5CrNiMo 19-11-2	1.4408	0,07 max.	1,50 max.	1,50 max.	0,040	0,030	18,00 to 20,00	2,00 to 2,50	9,00 to 12,00	0,50 max.	-	-	-
	GX5CrNiMoNb19-11-2	1.4581	0,07 max.	1,50 max.	1,50 max.	0,040	0,030	18,00 to 20,00	2,00 to 2,50	9,00 to 12,00	0,50 max.	-	-	Nb [d]
	GX2NiCrMo28-20-2	1.4458	0,030 max.	1,00 max.	2,00 max.	0,035	0,025	19,00 to 22,00	2,00 to 2,50	26,00 to 30,00	2,00 max.	0,20 max.	-	
	GX10NiCrSiNb32-20	1.4859	0,05 to 0,15	0,50 to 1,50	2,00 max.	0,040	0,030	19,00 to 21,00	0,50 max.	31,00 to 33,00	0,50 max	-	-	Nb 0,5 to 1,5
	GX2CrNiMoN22-5-3	1.4470	0,030 max.	1,00 max.	2,00 max.	0,035	0,025	21,00 to 23,00	2,50 to 3,50	4,50 to 6,50	0,50 max.	0,12 to 0,20	-	
	GX2CrNiMoCuN25-6-3-3	1.4517	0,030 max.	1,00 max.	1,50 max.	0,035	0,025	24,50 to 26,50	2,50 to 3,50	5,00 to 7,00	2,75 to 3,50	0,12 to 0,22	-	
	GX2CrNiMoN25-7-3	1.4417	0,030 max.	1,00	1,50	0,030	0,020	24,00 to 26,00	3,00 to 4,00	6,00 to 8,50	1,00 max.	0,15 to 0,25	-	W = 1,00 max.
	GX2CrNiMoN26-7-4 e	1.4469	0,030 max.	1,00 max.	1,00 max.	0,035	0,025	25,00 to 27,00	3,00 to 5,00	6,00 to 8,00	1,30 max.	0,12 to 0,22	-	

a For castings of ruling thickness < 28 mm, 0,030 S % is permitted.

b Cr + Mo + Ni + V + Cu ≤ 1,00 %

c For each reduction of 0,01 % below the specified maximum carbon content, an increase of 0,04 % manganese above the specified maximum content is permitted up to a maximum of 1,40 %.

d Niobium: The Nb content shall be between 8 times the C content % present of the alloy and 1 % max.

e For this steel grade a minimum value of the "pitting index" may be required as Pi = Cr + 3,3 Mo + 16N ≥ 40.

Table 3 — Mechanical properties at room temperature

	Designation		Heat treatment [a]			Thickness t mm	Tensile test				Impact test
							$R_{p0,2}$ MPa* min.	$R_{p1,0}$ [b] MPa* min.	R_m MPa*	A % min.	KV J min.
	Name	Number	Symbol [c]	Normalizing (+N)or Quenching (+Q) or solution annealing (+AT) °C	Tempering °C						
Ferritic and martensitic	GP240GH	1.0619	+ N	900 to 980	-	$t \leq 100$	240	-	420 to 600	22	27
			+ QT	890 to 980	600 to 700	$t \leq 100$	240	-	420 to 600	22	40
	GP280GH	1.0625	+ N	900 to 980	-	$t \leq 100$	280	-	480 to 640	22	27
			+ QT	890 to 980	600 to 700	$t \leq 100$	280	-	480 to 640	22	35
	G17Mn5	1.1131	+ QT	890 to 980	600 to 700	$t \leq 50$	240	-	450 to 600	24	-
	G20Mn5	1.6220	+ N	900 to 980	-	$t \leq 30$	300	-	480 to 620	20	-
			+ QT	900 to 940	610 to 660	$t \leq 100$	300	-	500 to 650	22	-
	G18Mo5	1.5422	+ QT	920 to 980	650 to 730	$t \leq 100$	240	-	440 to 790	23	-
	G20Mo5	1.5419	+ QT	920 to 980	650 to 730	$t \leq 100$	245	-	440 to 590	22	27
	G17CrMo5-5	1.7357	+ QT	920 to 960	680 to 730	$t \leq 100$	315	-	490 to 690	20	27
	G17CrMo9-10	1.7379	+ QT	930 to 970	680 to 740	$t \leq 150$	400	-	590 to 740	18	40
	G12MoCrV5-2	1.7720	+ QT	950 to 1 000	680 to 720	$t \leq 100$	295	-	510 to 660	17	27

"to be continued"

Table 3 (*continued*)

	Designation		Heat treatment [a]			Thickness t mm	Tensile test				Impact test
							$R_{p0,2}$ MPa* min.	$R_{p1,0}$ [b] MPa* min.	R_m MPa*	A % min.	KV J min.
	Name	Number	Symbol [c]	Normalizing (+N)or Quenching (+Q) or solution annealing (+AT) °C	Tempering °C						
Ferritic and martensitic	G17CrMoV5-10	1.7706	+ QT	920 to 960	680 to 740	$t \leq 150$	440	-	590 to 780	15	27
	G9Ni10	1.5636	+ QT	830 to 890	600 to 650	$t \leq 35$	280	-	480 to 630	24	-
	G17NiCrMo13-6	1.6781	+ QT	890 to 930	600 to 640	$t \leq 200$	600	-	750 to 900	15	-
	G9Ni14	1.5638	+ QT	820 to 900	590 to 640	$t \leq 35$	360	-	500 to 650	20	-
	GX15CrMo5	1.7365	+ QT	930 to 990	680 to 730	$t \leq 150$	420	-	630 to 760	16	27
	GX8CrNi12[e]	1.4107	+ QT1	1 000 to 1 060	680 to 730	$t \leq 300$	355	-	540 to 690	18	45
			+ QT2	1 000 to 1 060	600 to 680	$t \leq 300$	500	-	600 to 800	16	40
	GX3CrNi13-4	1.6982	+ QT[d]	1 000 to 1 050	670 to 690 + 590 to 620	$t \leq 300$	500	-	700 to 900	15	50 [g]
	GX4CrNi13-4	1.4317	+ QT	1 000 to 1 050	590 to 620	$t \leq 300$	550	-	760 to 960	15	27 [g]
	GX23CrMoV12-1	1.4931	+ QT	1 030 to 1 080	700 to 750	$t \leq 150$	540	-	740 to 880	15	27
	GX4CrNiMo16-5-1	1.4405	+ QT	1 020 to 1 070	580 to 630	$t \leq 300$	540	-	760 to 960	15	60

"to be continued"

Table 3 (*continued*)

	Designation		Heat treatment [a]			Thickness t mm	Tensile test				Impact test
							$R_{p0,2}$ MPa* min.	$R_{p1,0}$ [b] MPa* min.	R_m MPa*	A % min.	KV J min.
	Name	Number	Symbol [c]	Normalizing (+N)or Quenching (+Q) or solution annealing (+AT) °C	Tempering °C						
Austenitic and austenitic-ferritic	GX2CrNi19-11	1.4309	+ AT	1 050 to 1 150	-	$t \leq 150$	-	210	440 to 640	30	80 [g]
	GX5CrNi19-10	1.4308	+ AT	1 050 to 1 150	-	$t \leq 150$	-	200	440 to 640	30	60 [g]
	GX5CrNiNb19-11	1.4552	+ AT	1 050 to 1 150	-	$t \leq 150$	-	200	440 to 640	25	
	GX2CrNiMo19-11-2	1.4409	+ AT	1 080 to 1 150	-	$t \leq 150$	-	220	440 to 640	30	
	GX5CrNiMo19-11-2	1.4408	+ AT	1 080 to 1 150	-	$t \leq 150$	-	210	440 to 640	30	60 [g]
	GX5CrNiMoNb19-11-2	1.4581	+ AT	1 080 to 1 150	-	$t \leq 150$	-	210	440 to 640	25	40 [g]
	GX2NiCrMo28-20-2	1.4458	+ AT	1 100 to 1 180	-	$t \leq 150$	-	190	430 to 630	30	60 [g]
	GX10NiCrSiNb32-20	1.4859	- [h]	-	-	$t \leq 50$	180	-	440 to 640	25	27
						$50 < t \leq 150$	180	-	400 to 600 [i]	20 [j]	27

"to be continued"

Table 3 (*concluded*)

	Designation		Heat treatment [a]			Thickness t mm	Tensile test				Impact test
							$R_{p0,2}$ MPa* min.	$R_{p1,0}$ [b] MPa* min.	R_m MPa*	A % min.	KV J min.
	Name	Number	Symbol [c]	Normalizing (+N)or Quenching (+Q) or solution annealing (+AT) °C	Tempering °C						
Austenitic and austenitic-ferritic	GX2CrNiMoN22-5-3	1.4470	+ AT	1 120 to 1 150 [f]	-	$t \leq 150$	420	-	600 to 800	20	30 [g]
	GX3CrNiMoCuN25-6-3-3	1.4517	+ AT	1 120 to 1 150 [f]	-	$t \leq 150$	480	-	650 to 850	22	50 [g]
	GX2CrNiMoN25-7-3	1.4417	+ AT	1 120 to 1 150 [f]	-	$t \leq 150$	480	-	650 to 850	22	50 [g]
	GX2CrNiMoN26-7-4	1.4469	+ AT	1 140 to 1 180 [f]	-	$t \leq 150$	480	-	650 to 850	22	50 [g]

a Temperature (for information only).

b $R_{p0,2}$ may be estimated by lowering $R_{p1,0}$ by 25 MPa.

c + N means Normalizing; + QT or + QT1 or + QT2 means quenching (air or liquid) + tempering; AT means: solution annealing + water quenching

d Quenching in air.

e The requested alternative shall be indicated on the order e.g.: GX8CrNi12 + QT1 or 1.4107 + QT1.

f After solution annealing at high temperature, castings may be cooled down to between 1 050 °C and 1 010 °C prior to water quenching in order to improve corrosion resistance and prevent cracks in complex shapes.

g The low temperatures impact properties shall conform to Table 4 for ferritic and martensitic grades and may be agreed according to values of Table 5 for austenic and austenic-ferritic grades used at low temperatures.

h As cast conditions.

i For centricast, 440 MPa to 640 MPa.

j For centricast, 25 %.

* 1 MPa = 1 N/mm^2.

Table 4 — Impact test at low temperature for ferritic and martensitic grades (normative)

Designation		Heat treatment	Impact test	
Name	Number	Symbol	KV J min.	T °C
G17Mn5	1.1131	+ QT	27	- 40
G20Mn5		+ N	27	- 30
	1.6220	+ QT	27	- 40
G18Mo5	1.5422	+ QT	27	- 45
G9Ni10	1.5636	+ QT	27	- 70
G17NiCrMo13-6	1.6781	+ QT	27	- 80
G9Ni14	1.5638	+ QT	27	- 90
GX3CrNi13-4	1.6982	+ QT	27	- 120

Table 5 — Impact test at low temperature for austenitic and austenitic-ferritic grades (optional)

Designation		Heat treatment	Impact test	
Name	Number	Symbol	KV J min.	T °C
GX2CrNi19-11	1.4309	+ AT	70	- 196
GX5CrNi19-10	1.4308	+ AT	60	- 196
GX2CrNiMo19-11-2	1.4409	+ AT	70	- 196
GX5CrNiMo19-11-2	1.4408	+ AT	60	- 196
GX2NiCrMo28-20-2	1.4458	+ AT	60	- 196
GX3CrNiMoCuN25-6-3-3	1.4517	+ AT	35	- 70
GX2CrNiMoN25-7-3	1.4417	+ AT	35	- 70
GX2CrNiMoN26-7-4	1.4469	+ AT	35	- 70

Table 6 — Tensile test at elevated temperatures (verification by agreement at the time of enquiry and order)

	Designation		Heat treatment	Proof strength test at elevated temperature $R_{p0,2}$ MPa * min.							
	Name	Number	Symbol	100 °C	200 °C	300 °C	350 °C	400 °C	450 °C	500 °C	550 °C
Ferritic and martensitic	GP240GH	1.0619	+ N	210	175	145	135	130	125	-	-
			+ QT	210	175	145	135	130	125	-	-
	GP280GH	1.0625	+ N	250	220	190	170	160	150	-	-
			+ QT	250	220	190	170	160	150	-	-
	G20Mo5	1.5419	+ QT	-	190	165	155	150	145	135	-
	G17CrMo5-5	1.7357	+ QT	-	250	230	215	200	190	175	160
	G17CrMo9-10	1.7379	+ QT	-	355	345	330	315	305	280	240
	G12MoCrV5-2	1.7720	+ QT	264	244	230	-	214	-	194	144
	G17CrMoV5-10	1.7706	+ QT	-	385	365	350	335	320	300	260
	GX15CrMo5	1.7365	+ QT	-	390	380	-	370	-	305	250
	GX8CrNi12	1.4107	+ QT1	-	275	265	-	255	-	-	-
			+ QT 2	-	410	390	-	370	-	-	-
	GX4CrNi13-4	1.4317	+ QT	515	485	455	440	-	-	-	-
	GX23CrMoV12-1	1.4931	+ QT	-	450	430	410	390	370	340	290
	GX4CrNiMo16-5-1	1.4405	+ QT	515	485	455	-	-	-	-	-
Austenitic and austenitic-ferritic				$R_{p1,0}$ [a] MPa * min.							
				100 °C	200 °C	300 °C	350 °C	400 °C	450 °C	500 °C	500 °C
	GX2CrNi19-11	1.4309	+ AT	165	130	110	100	-	-	-	-
	GX5CrNi19-10	1.4308	+ AT	160	125	110	-	-	-	-	-
	GX5CrNiNb19-11	1.4552	+ AT	165	145	130	-	120	-	110	100
	GX2CrNiMo19-11-2	1.4409	+ AT	175	145	115	-	105	-	-	-
	GX5CrNiMo19-11-2	1.4408	+ AT	170	135	115	-	105	-	-	-
	GX5CrNiMoNb19-11-2	1.4581	+ AT	185	160	145	-	130	-	120	115
	GX2NiCrMo28-20-2	1.4458	+ AT	165	135	120	-	110	-	-	-
	GX10NiCrSiNb32-20	1.4859	-	155	135	125	-	120	-	110	107
	GX2CrNiMoN22-5-3	1.4470	+ AT	330 [b]	280 [b]	c	c	c	c	c	c
	GX3CrNiMoCuN25-6-3-3	1.4517	+ AT	390 [b]	330 [b]	c	c	c	c	c	c
	GX2CrNiMoN25-7-3	1.4417	+ AT	390 [b]	330 [b]	c	c	c	c	c	c
	GX2CrNiMoN26-7-4	1.4469	+ AT	390 [b]	330 [b]	c	c	c	c	c	c

a $R_{p0,2}$ may be estimated by lowering $R_{p1,0}$ by 25 MPa.

b $R_{p0,2}$ values instead of $R_{p1,0}$.

c The austenitic-ferritic steels are not to be used for temperatures higher than 250 °C in pressure vessel applications.

* 1 MPa = 1 N/mm^2

Annex A

Welding conditions

Annex A is normative for austenitic and austenitic-ferritic grades.

Annex A is informative for ferritic and martensitic grades.

Table A.1 — Welding conditions

	Designation		Preheat temperature °C [a]	Interpass temperature °C max.	Post heat treatment °C		
	Name	Number					
Ferritic and martensitic	GP240GH	1.0619	20 to 150	350	No heat treatment necessary		Informative
	GP280GH	1.0625	20 to 150	350	No heat treatment necessary		
	G17Mn5	1.1131	20 to 150	350	No heat treatment necessary		
	G20Mn5	1.6220	20 to 150	350	No heat treatment necessary		
	G18Mo5	1.5422	20 to 200	350	≥ 650		
	G20Mo5	1.5419	20 to 200	350	≥ 650		
	G17CrMo5-5	1.7357	150 to 250	350	≥ 650		
	G17CrMo9-10	1.7379	150 to 250	350	≥ 680		
	G12MoCrV5-2	1.7720	200 to 300	400	≥ 680		
	G17CrMoV5-10	1.7706	200 to 300	400	≥ 680		
	G9Ni10	1.5636	20 to 150	350	≥ 570		
	G17NiCrMo13-6	1.6781	20 to 200	350	≥ 580		
	G9Ni14	1.5638	20 to 200	300	≥ 560		
	GX15CrMo5	1.7365	150 to 250	350	≥ 650		
	GX8CrNi12	1.4107	100 to 200	350	Same as normal tempering temperature		
	GX3CrNi13-4	1.6982	20 to 200	[b]	[b]		
	GX4CrNi13-4	1.4317	100 to 200	300	Same as normal tempering temperature		
	GX23CrMoV12-1	1.4931	200 to 450	450	≥ 680 °C after cooling under 80 °C to 130°C		
	GX4CrNiMo16-5-1	1.4405	No preheat	200	Same as normal tempering temperature		
Austenitic and austenitic- ferritic					Minor welds [c]	Major welds [d]	normative
	GX2CrNi19-11	1.4309	No preheat	[b]	No heat tr. necess.	No heat tr. necess. [e]	
	GX5CrNi19-10	1.4308			+AT [f g]		
	GX5CrNiNb19-11	1.4552			No heat tr. necess., but [h]		
	GX2CrNiMo19-11-2	1.4409			No heat tr. necess.	No heat tr. necess. [e]	
	GX5CrNiMo19-11-2	1.4408			+At [f g]		
	GX5CrNiMoNb19-11-2	1.4581			No heat tr. necess., but [h]		
	GX2NiCrMo28-20-2	1.4458	20 to 100	150	No heat tr. necess., but [c]	+AT [i]	
	GX10NiCrSiNb32-20	1.4859	No preheat	200	For wall thickness > 80 mm, annealing at ≥ 850 °C is necessary to reduce residual stresses		
	GX2CrNiMoN22-5-3	1.4470	20 to 100	250	+ AT [i j]	+ AT [i j]	
	GX3CrNiMoCuN25-6-3-3	1.4517	20 to 100	250	+ AT [i j]	+ AT [i j]	
	GX2CrNiMoN25-7-3	1.4417	20 to 100	250	+ AT [i j]	+ AT [i j]	
	GX2CrNiMoN26-7-4	1.4469	20 to 100	250	+ AT [i j]	+ AT [i j]	

[a] The preheating temperature is related to the geometry and the thickness of the casting and climate conditions.

[b] At the discretion of the manufacturer unless otherwise agreed.

[c] For minor welds, where applicable, special arrangement shall be agreed upon according to corrosion conditions.

[d] In general production welds are considered major when the depth of the cavity prepared for welding exceeds 40 % of the wall thickness.

[e] For use at low temperature + AT is required.

[f] The heat treatment for all the mentioned steels is + AT (solution annealing); it is usually made by liquid quenching or by air quenching if so agreed for very small and thin castings.

[g] For use at high temperature + AT may be suppressed.

[h] For improving the corrosion resistance a special stabilising heat treatment (stress relieve and carbide precipitation) in the range of 600 °C to 650 °C for GX5CrNiNb19-11 and 550 °C to 600 °C for GX5CrNiMoNb19-11-2 may be agreed.

[i] + AT may only be suppressed if welding is performed with restricted heat input conditions.

[j] The heat treatment for all the mentioned steels is + AT (solution annealing). Air Quenching may be agreed for very small and thin castings. After solution annealing at high temperatures, castings may be cooled down to between 1 050 °C and 1 010 °C prior to water quenching in order to improve corrosion resistance and prevent cracks in complex shapes.

Annex B
(informative)

Physical properties

Information on physical properties of steel grades is given in Table B.1.

Table B.1 — Physical properties (informative)

Designation		Density kg/dm^3 at	Mean thermal expansion 10^{-6} K^{-1} from			Thermal conductivity W/(m·K) at		Specific heat J/(kg·K) at	Magnetic properties
			20 °C to	20 °C to	20 °C to				
Name	Number	20 °C	100 °C	300 °C	500 °C	50 °C	100 °C	20 °C	
GP240GH	1.0619	7,8	12,6	13,4	14	45	-	460	Magnetic
GP280GH	1.0625	7,8	12,8	13,6	14,5	45	-	460	
G17Mn5	1.1131	7,8	13,0	13,8	15	45	-	460	
G20Mn5	1.6220	7,8	13,0	13,8	15	45	-	460	
G18Mo5	1.5422	7,85	12,4	13,1	13,8	43	-	460	
G20Mo5	1.5419	7,85	12,4	13,1	13,8	43	-	460	
G17CrMo5-5	1.7357	7,85	11,8	12,9	13,7	38,5	-	460	
G17CrMo9-10	1.7379	7,85	11,8	12,6	13,4	-	-	460	
G12MoCrV5-2	1.7720	7,85	-	-	-	-	-	460	
G17CrMoV5-10	1.7706	7,85	12,4	13,6	14,5	-	-	460	
G9Ni10	1.5636	7,85	11,8	12,4	13,6	36	-	460	
G17NiCrMo13-6	1.6781	7,85	-	-	-	-	-	460	
G9Ni14	1.5638	7,85	-	-	-	-	-	460	
GX15CrMo5	1.7365	7,8	11,8	12,3	12,7	30,1	-	460	
GX8CrNi12	1.4107	7,7	10,5	11,5	12,3	26	27	460	
GX4CrNi13-4	1.4317	7,7	10,5	11	12	26	27	460	
GX3CrNi13-4	1.6982	7,7	10,5	11	12	26	27	460	
GX23CrMoV12-1	1.4931	7,7	-	-	-	-	-	460	
GX4CrNiMo16-5-1	1.4405	7,8	10,8	11,5	12	17	18	460	
GX2CrNi19-11	1.4309	7,88	16,8	17,9	18,6	15,2	16,5	530	Non to slight magnetic
GX5CrNi19-11	1.4308	7,88	16,8	17,9	18,6	15,2	16,5	530	
GX5CrNiNb19-11	1.4552	7,88	16,8	17,9	18,6	15,2	16,5	530	
GX2CrNiMo19-11-2	1.4409	7,9	15,8	17	17,7	14,5	15,8	530	
GX5CrNiMo19-11-2	1.4408	7,9	15,8	17	17,7	14,5	15,8	530	
GX5CrNiMoNb19-11-2	1.4581	7,9	15,8	17	17,7	14,5	15,8	530	
GX2NiCrMo28-20-2	1.4458	8,0	14,5	16,2	17	16	17	500	
GX10NiCrSiNb 32-20	1.4859	8,0	-	15	16,3	12,1	13,1	500	
GX2CrNiMoN22-5-3	1.4470	7,7	13	14	-	18	18	450	Appreciably magnetic
GX3CrNiMoCuN25-6-3-3	1.4517	7,7	13	14	-	17	18	450	
GX2CrNiMoN25-7-3	1.4417	7,7	13	14	-	17	18	450	
GX2CrNiMoN26-7-4	1.4469	7,7	13	14	-	17	18	450	

Annex C
(informative)

Creep properties

Information on creep properties for some grades used at high temperature is given in Table C.1.

Table C.1 — Creep resistance (mean values)
σ_r: rupture stress, MPa *,
σ_{A1} creep stress, MPa * at 1 % elongation

Designation		Temperature °C	400 °C			450 °C			500 °C			550 °C			600 °C			650 °C		700 °C	
Name	Number	Time hour	10 000	100 000	200 000	10 000	100 000	200 000	10 000	100 000	200 000	10 000	100 000	200 000	10 000	100 000	200 000	10 000	100 000	10 000	100 000
GP240GH	1.0619	σ_r	205	160	145	132	83	71	74	40	32	-	-	-	-	-	-	-	-	-	-
		σ_{A1}	147	110	-	88	50	-	43	20	-	-	-	-	-	-	-	-	-	-	-
GP280GH	1.0625	σ_r	210	165	-	135	85	-	75	42	-	-	-	-	-	-	-	-	-	-	-
		σ_{A1}	148	110	-	90	52	-	45	22	-	-	-	-	-	-	-	-	-	-	-
G20Mo5	1.5419	σ_r	360	310	290	275	205	180	160	85	70	66	30	23	-	-	-	-	-	-	-
		σ_{A1}	-	-	-	185	150	130	125	65	50	41	15	10	-	-	-	-	-	-	-
G17CrMo5-5	1.7357	σ_r	420	370	356	321	244	222	187	117	96	98	55	44	-	-	-	-	-	-	-
		σ_{A1}	271	222	-	196	145	-	130	81	-	65	35	-	-	-	-	-	-	-	-
G17CrMo9-10	1.7379	σ_r	404	324	304	282	218	200	188	136	120	106	66	52	58	28	22	-	-	-	-
		σ_{A1}	350	300	278	229	168	148	141	96	80	70	40	31	36	18	14	-	-	-	-
G12MoCrV5-2	1.7720	σ_r	-	-	-	365	277	-	208	140	-	135	75	-	89	-	-	-	-	-	-
G17CrMoV5-10	1.7706	σ_r	463	419	395	340	275	254	229	171	157	151	96	83	80	28	19	-	-	-	-
		σ_{A1}	427	385	356	305	243	218	196	133	110	120	70	49	50	18	10	-	-	-	-
GX15CrMo5 [a]	1.7365	σ_r	-	-	-	228 [a]	165 [a]	-	168	106	-	93	58	-	51	-	-	-	-	-	-
GX23CrMoV12-1	1.4931	σ_r	504	426	394	383	309	279	269	207	187	167	118	103	83	49	39	-	-	-	-
		σ_{A1}				305	259	239	216	172	153	131	91	77	66	34	25	-	-	-	-
GX5CrNi19-10	1.4308	σ_r	-		-	-	-	-	-	-	-	147	124	-	110	83	-	73	52	47	-
GX5CrNiNb19-11	1.4552	σ_r	-	-	-	-	-	-	-	-	-	246	192	-	156	124	-	109	80	73	-
GX5CrNiMo19-11-2	1.4408	σ_r	-	-	-	-	-	-	-	-	-	194	160	-	148	113	-	103	66	60	42
GX10NiCrSiNb32-20	1.4859	σ_r	-	-	-	-	-	-	-	-	-	-	-	-	122	-	-	-	-	85,7	71,3
		σ_{A1}	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	64	-

[a] σ_r at 470 °C.

* 1 MPa = 1 N/mm^2

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 – Pressure Equipment Directive (P.E.D).

Once this standard is cited in the Official Journal of the European Communities 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 Directive 97/23/EC – Pressure Equipment Directive (P.E.D)

Clause(s)/subclause(s) of this EN	Essential Requirements (ERs) of Directive 97/23//EC	Qualifying remarks/Notes
6.2	3.1.2 "Annex 1"	Permanent joining
7.2.1 and 7.2.2	4.1a "Annex 1"	Material properties
8.1	4.3 "Annex 1"	Certificates

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

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