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ISO 4991

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Steel castings for pressure purposes

Pièces moulées en acier pour service sous pression

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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).

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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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is The committee responsible for this document is ISO/TC 17, *Steel*, Subcommittee SC 11, *Steel castings*.

This third edition cancels and replaces the second edition (ISO 4991:2005), which has been technically revised. In particular, the following changes have been made:

— new and replacement International Standards have been added to the normative references (see Clause 2);

— a new numbering system has been included in all tables;

— in Table 1, grade designations and composition limits have been changed where appropriate.

— a new Annex D containing Table D.1, showing UNS grades similar to ISO cast grades, has been added.

Steel castings for pressure purposes

1 Scope

This International Standard covers steel castings for pressure containing parts.

It includes materials which are used for the manufacture of components subject to pressure vessel codes and components not subject to codes.

This International Standard relates to castings manufactured from unalloyed and alloyed steel grades (characterized by their chemical composition, Table 1, and mechanical properties, Tables 2, 3, 4 and 5).

NOTE Annex D gives information on ISO grade designation and available UNS numbers which are similar to the ISO grade designation.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 4885, *Ferrous products — Heat treatments — Vocabulary*

ISO 4990, *Steel castings — General technical delivery requirements*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO 6892-2, *Metallic materials — Tensile testing — Part 2: Method of test at elevated temperature*

ISO 11970, *Specification and approval of welding procedures for production welding of steel castings*

ISO 13520, *Determination of ferrite content in austenitic stainless steel castings*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4885 and ISO 4990 apply.

4 Information to be supplied by the purchaser

Materials specified in this International Standard shall conform to the applicable requirements of ISO 4990 including the supplementary requirements listed in Annex A that are indicated in the enquiry and purchase order.

5 Heat treatment

The type of heat treatment shall comply with Table 6 for the specified grades. The temperatures given are for information only.

When a grade may be delivered at different strength levels depending on the type of heat treatment (see Table 2), the purchaser shall state at the time of enquiry and order the type of heat treatment required.

The symbols for the type of heat treatment are as follows:

+N normalized

+QT quenched and tempered

+AT solution annealed

NOTE For definitions, see ISO 4885.

6 Welding

Welding is permitted, unless otherwise agreed. All the welds shall conform to the same criteria for non-destructive testing as the relevant part of the casting. Welding shall be carried out in accordance with ISO 11970.

The welding conditions are given in Annex B.

7 Requirements

7.1 Chemical composition

An analysis of each heat shall be made by the manufacturer to determine the contents of the specified elements.

The chemical composition shall comply with the values given in Table 1.

Permissible deviations for the product analysis are indicated in ISO 4990.

7.2 Mechanical properties

The mechanical properties shall comply with the values given in Tables 2, 3, 4 and 5.

Mechanical properties shall be measured on test pieces taken from test blocks (according to ISO 4990).

The tensile tests at room temperature shall be carried out according to ISO 6892-1 and, if specified, impact tests according to ISO 148-1.

If required by agreement at the time of enquiry and order, impact energy properties at low temperature shall comply with Table 3.

If required by agreement at the time of enquiry and order, impact energy values at room temperature shall comply with Table 4.

If required by agreement at the time of enquiry and order, verification of the elevated temperature proof stress values shall be carried out at elevated temperatures in accordance with ISO 6892-2. In such a case, the values shall comply with Table 5.

Creep resistance mean values are given for information, for some grades in Annex C.

8 Inspection and testing

8.1 General

For all products ordered to the requirements of this International Standard, specific inspection and testing is required.

8.2 Sampling

Test blocks shall be heat treated in production furnaces to the same procedure as the castings they represent.

Test pieces shall not be cut from the test block until the latter has been heat treated.

8.3 Formation of test lots

The formation of test lots shall be carried out in accordance with ISO 4990.

8.4 Non-destructive testing

The following information shall be given at the time of enquiry and order in accordance with ISO 4990:

— non-destructive methods required,

— area to be examined,

— acceptance criteria required.

8.5 Marking

8.5.1 Castings shall be marked for material identification. In addition, heat numbers, or serial numbers that are traceable to heat numbers, shall be marked on all castings. For small castings, it may be agreed at the time of the enquiry and order that they may be batched and that their identification is marked on a label attached to each batch.

8.5.2 Castings shall be marked with the manufacturer's identification or symbol except where other provisions have been made between the manufacturer and purchaser.

8.5.3 When more than one heat treatment type is available, the heat treatment applied shall be marked with a suffix added to the grade designation (see Table 2).

9 Supplementary requirements

This International Standard also specifies supplementary requirements, which may be applied to steel castings. These requirements are provided for use when additional testing or inspection is desired and apply only when individually specified by the purchaser.

A list of supplementary requirements which may be used at the option of the purchaser is given in ISO 4990 and in Annex A.

If ferrite determination is required for austenitic and austenitic-ferritic grades, it may be made using ISO 13520.

Table 1 — Chemical composition, in per cent, mass fraction

Grade designation		C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Other
Name	Number		max.		max.	max.						
GP240GH	1.0619	0,18–0,23[a]	0,60	0,50–1,20 [a]	0,030	0,020	0,30 max.	0,12 max.	0,40 max.	0,03 max.	0,30 max.	[b]
GP280GH	1.0625	0,18–0,25[a]	0,60	0,80–1,20 [a]	0,030	0,020	0,30 max.	0,12 max.	0,40 max.	0,03 max.	0,30 max.	[b]
G17Mn5	1.1131	0,15–0,20	0,60	1,00–1,60	0,020	0,025	0,30 max.	0,12 max.	0,40 max.	0,03 max.	0,30 max.	[b]
G20Mn5	1.6220	0,17–0,23	0,60	1,00–1,60	0,020	0,020	0,30 max.	0,12 max.	0,80 max.	0,03 max.	0,30 max.	
G18Mo5	1.5422	0,15–0,20	0,60	0,80–1,20	0,020	0,020	0,30 max.	0,45–0,65	0,40 max.	0,050 max.	0,30 max.	
G20Mo5	1.5419	0,15–0,23	0,60	0,50–1,00	0,025	0,020	0,30 max.	0,40–0,60	0,40 max.	0,050 max.	0,30 max.	
G17CrMo5–5	1.7357	0,15–0,20	0,60	0,50–1,00	0,020	0,020	1,00–1,50	0,45–0,65	0,40 max.	0,050 max.	0,30 max.	
G17CrMo9–10	1.7379	0,13–0,20	0,60	0,50–0,90	0,020	0,020	2,00–2,50	0,90–1,20	0,40 max.	0,050 max.	0,30 max.	
G12MoCrV5–2	1.7720	0,10–0,15	0,45	0,40–0,70	0,030	0,020	0,30–0,50	0,40–0,60	0,40 max.	0,22–0,30	0,30 max.	
G17CrMoV5–10	1.7706	0,15–0,20	0,60	0,50–0,90	0,020	0,015	1,20–1,50	0,90–1,10	0,40 max.	0,20–0,30	0,30 max.	
G25NiCrMo3	1.6553	0,23–0,28	0,80	0,60–1,00	0,030	0,025	0,40–0,80	0,15–0,30	0,40–0,80	0,03 max.	0,30 max.	
G25NiCrMo6	1.6554	0,23–0,28	0,60	0,60–0,90	0,030	0,025	0,70–0,90	0,20–0,30	1,00–2,00	0,03 max.	0,30 max.	
G17NiCrMo13–6	1.6781	0,15–0,19	0,50	0,55–0,80	0,015	0,015	1,30–1,80	0,45–0,60	3,00–3,50	0,050 max.	0,30 max.	
G9Ni10	1.5636	0,06–0,12	0,60	0,50–0,80	0,020	0,015	0,30 max.	0,20 max.	2,00–3,00	0,050 max.	0,30 max.	
G9Ni14	1.5638	0,06–0,12	0,60	0,50–0,80	0,020	0,015	0,30 max.	0,20 max.	3,00–4,00	0,050 max.	0,30 max.	
GX15CrMo5	1.7365	0,12–0,19	0,80	0,50–0,80	0,025	0,025	4,00–6,00	0,45–0,65	-	0,05	0,30 max.	
GX10CrMoV9–1	1.7367	0,08–0,12	0,20–0,50	0,30–0,60	0,030	0,010	8,0–9,5	0,85–1,05	0,40 max	0,18–0,25	-	Nb 0,060–0,10 N 0,030–0,070 Al 0,02max Ti 0,01 max Zr 0,01 max
GX15CrMo9–1	1.7376	0,12–0,19	1,00	0,35–0,65	0,030	0,030	8,00–10,00	0,90–1,20	0,40 max.	0,05	0,30 max.	
GX8CrNi12–1	1.4107	0,10 max.	0,40	0,50–0,80	0,030	0,020	11,50–12,50	0,50 max.	0,80–1,50	0,08 max.	0,30 max.	
GX23CrMoV12–1	1.4931	0,20–0,26	0,40	0,50–0,80	0,030	0,020	11,30–12,20	1,00–1,20	1,00 max.	0,25–0,35	0,30 max.	W 0,50 max
GX3CrNi13–4	1.6982	0,05 max.	1,00	1,00 max.	0,035	0,015	12,00–13,50	0,70 max.	3,50–5,00	0,08 max.	0,30 max.	
GX4CrNi13–4	1.4317	0,06 max.	1,00	1,00 max.	0,035	0,025	12,00–13,50	0,70 max.	3,50–5,00	0,08 max.	0,30 max.	
GX4CrNiMo16–5-1	1.4405	0,06 max.	0,80	1,00 max.	0,035	0,025	15,00–17,00	0,70–1,50	4,00–6,00	0,08 max.	0,30 max.	

[a] For each reduction of 0,01 % carbon below the maximum specified, an increase of 0,04 % manganese above the maximum specified will be permitted to a maximum of 1,40 %.

[b] %Cr + %Mo + %Ni + %V + %Cu ≤ 1,00 %.

Table 1 *(continued)*

Grade designation		C	Si	Mn	P	S	Cr	Mo	Ni	V	Cu	Other
Name	Number		max.		max.	max.						
GX2CrNiN19–11	1.4487	0,030 max.	1,50	2,00 max.	0,035	0,030	18,00–20,00	-	9,00–12,00	-	0,50 max.	$0,12 \leq N \leq 0,20$
GX5CrNi19–10	1.4308	0,07 max.	1,50	1,50 max.	0,040	0,030	18,00–20,00	-	8,00–11,00	-	0,50 max.	
GX5CrNiNb19–11	1.4552	0,07 max.	1,50	1,50 max.	0,040	0,030	18,00–20,00	-	9,00–12,00	-	0,50 max.	$8xC \leq Nb \leq 1,00$
GX2CrNiMoN19–11–2	1.4490	0,030 max.	1,50	2,00 max.	0,035	0,030	18,00–20,00	2,00–2,50	9,00–12,00	-	0,50 max.	$0,12 \leq N \leq 0,20$
GX5CrNiMo19–11–2	1.4408	0,07 max.	1,50	1,50 max.	0,040	0,030	18,00–20,00	2,00–2,50	9,00–12,00	-	0,50 max.	
GX5CrNiMoNb19–11–2	1.4581	0,07 max.	1,50	1,50 max.	0,040	0,030	18,00–20,00	2,00–2,50	9,00–12,00	-	0,50 max.	$8xC \leq Nb \leq 1,00$
GX2CrNiMoN22–5-3	1.4470	0,030 max.	1,00	2,00 max.	0,035	0,025	21,00–23,00	2,50–3,50	4,50–6,50	-	0,50 max.	$0,12 \leq N \leq 0,20$
GX2CrNiMoCuN26–5-3–3	1.4451	0,030 max.	1,00	1,50 max.	0,035	0,025	25,00–27,00	2,50–3,50	5,00–7,00	-	2,75–3,50	$0,12 \leq N \leq 0,22$
GX2CrNiMoN26–7-4	1.4469	0,030 max.	1,00	1,00 max.	0,035	0,025	25,00–27,00	3,00–5,00	6,00–8,00	-	1,30 max.	$0,12 \leq N \leq 0,22$
GX2NiCrMo28–20–2	1.4458	0,030 max.	1,00	2,00 max.	0,035	0,025	19,00–22,00	2,00–2,50	26,00–30,00	-	2,00 max.	$N \leq 0,20$

[a] For each reduction of 0,01 % carbon below the maximum specified, an increase of 0,04 % manganese above the maximum specified will be permitted to a maximum of 1,40 %.

[b] %Cr + %Mo + %Ni + %V + %Cu ≤ 1,00 %.

Table 2 — Tensile properties at room temperature

Grade designation		Type of heat treatment [a]	$R_{p0,2}$ MPa min.	$R_{p1,0}$ MPa min.	R_m MPa	A % min.
Name	Number					
GP240GH	1.0619	+N[b]	240	-	420-600	22
GP240GH	1.0619	+QT	240		420–600	22
GP280GH	1.0625	+N [b]	280	-	480–640	22
GP280GH	1.0625	+QT	280		480–640	22
G17Mn5	1.1131	+QT	240	-	450–600	24
G20Mn5	1.6220	+N [b]	300	-	480–620	20
G20Mn5	1.6220	+QT	300	-	500–650	22
G18Mo5	1.5422	+QT	240	-	440–590	23
G20Mo5	1.5419	+QT	245	-	440–690	22
G17CrMo5–5	1.7357	+QT	315	-	490–690	20
G17CrMo9–10	1.7379	+QT	400	-	590–740	18
G12MoCrV5–2	1.7720	+QT	295	-	510–660	17
G17CrMoV5–10	1.7706	+QT	440	-	590–780	15
G25NiCrMo3	1.6553	+QT1	415	-	620–795	18
G25NiCrMo3	1.6553	+QT2	585		725–865	17
G25NiCrMo6	1.6554	+QT1	485	-	690–860	18
G25NiCrMo6	1.6554	+QT2	690	-	860–1 000	15
G17NiCrMo13–6	1.6781	+QT	600	-	750–900	15
G9Ni10	1.5636	+QT	280	-	480–630	24
G9Ni14	1.5638	+QT	360	-	500–650	20
GX15CrMo5	1.7365	+QT	420	-	630–760	16
GX10CrMoV9–1	1.7367	+NT	415	-	585–760	16
GX15CrMo9–1	1.7376	+QT	415	-	620–795	18
GX8CrNi12–1	1.4107	+QT1	355	-	540–690	18
GX8CrNi12–1	1.4107	+QT2	500	-	600–800	16
GX23CrMoV12–1	1.4931	+QT	540	-	740–880	15
GX3CrNi13–4	1.6982	+QT	500	-	700–900	15
GX4CrNi13–4	1.4317	+QT	550	-	760–960	15
GX4CrNiMo16–5–1	1.4405	+QT	540	-	760–960	15
GX2CrNiN19–11	1.4487	+AT	-	230	440–640	30
GX5CrNi19–9	1.4308	+AT	-	200	440–640	30
GX6CrNiNb19–10	1.4552	+AT	-	200	440–640	25
GX2CrNiMoN19–11–2	1.4490	+AT	-	230	440–640	30
GX5CrNiMo19–11–2	1.4408	+AT	-	210	440–640	30
GX6CrNiMoNb19–11–2	1.4581	+AT	-	210	440–640	25
GX2CrNiMoN22–5-3	1.4470	+AT	420	-	600–800	20

[a] The type of heat treatment is mandatory.

[b] Tempering is permitted.

NOTE 1 MPa = 1 N/mm^2

Table 2 *(continued)*

Grade designation		Type of heat treatment [a]	$R_{p0,2}$ MPa min.	$R_{p1,0}$ MPa min.	R_m MPa	A % min.
Name	Number					
GX2CrNiMoCuN26–5-3–3	1.4451	+AT	480	-	650–850	22
GX2CrNiMoN26–7-4	1.4469	+AT	480	-	650–850	22
GX2NiCrMo28–20–2	1.4458	+AT	-	190	430–630	30

[a] The type of heat treatment is mandatory.

[b] Tempering is permitted.

NOTE 1 MPa = 1 N/mm^2

Table 3 — Impact properties at low temperatures

Grade designation		Type of heat treatment	KV J min.	°C
Name	Number			
G17Mn5	1.1131	+ QT	27	–40
G20Mn5	1.6220	+ N	27	–30
G20Mn5	1.6220	+ QT	27	–40
G18Mo5	1.5422	+ QT	27	–45
G17NiCrMo13–6	1.6781	+ QT	27	–80
G9Ni10	1.5636	+ QT	27	–70
G9Ni14	1.5638	+ QT	27	–90
GX3CrNi13–4	1.6982	+ QT	27	–120
GX2CrNiN19–11	1.4487	+ AT	70	–196
GX5CrNi19–9	1.4308	+ AT	60	–196
GX2CrNiMoN19–11–2	1.4490	+ AT	70	–196
GX5CrNiMo19–11–2	1.4408	+ AT	60	–196
GX2CrNiMo22–5-3	1.4470	+ AT	40	–40
GX2CrNiMoCuN26–5-3–3	1.4451	+ AT	35	–70
GX2CrNiMoN26–7-4	1.4469	+ AT	35	–70
GX2NiCrMo28–20–2	1.4458	+ AT	60	–196

Table 4 — Impact properties at room temperature

Grade designation		Type of heat treatment	*KV* J
Name	Number		min.
GP240GH	1.0619	+ N	27
GP240GH	1.0619	+ QT	40
GP280GH	1.0625	+ N	27
GP280GH	1.0625	+ QT	40
G20Mo5	1.6220	+ QT	27
G17CrMo5–5	1.7357	+ QT	27
G17CrMo9–10	1.7379	+ QT	40
G12MoCrV5–10	1.7720	+ QT	27
G17CrMoV5–10	1.7706	+ QT	27
G25NiCrMo3	1.6553	+ QT1	27
G25NiCrMo3	1.6553	+ QT2	27
G25NiCrMo6	1.6554	+ QT1	27
G25NiCrMo6	1.6554	+ QT2	40
GX15CrMo5	1.7365	+ QT	27
GX15CrMo9–1	1.7376	+ QT	27
GX8CrNi12–1	1.4107	+ QT1	45
GX8CrNi12–1	1.4107	+ QT2	40
GX23CrMoV12–1	1.4931	+ QT	27
GX3CrNi13–4	1.6982	+ QT	50
GX4CrNi13–4	1.4317	+ QT	50
GX4CrNiMo16–5-1	1.4405	+ QT	60

Table 5 — Tensile properties at elevated temperatures

Grade designation		Type of heat treatment	R_p at elevated temperature °C (MPa[c])								
				100 °C	200 °C	300 °C	350 °C	400 °C	450 °C	500 °C	550 °C
Name	No.		R_p	min	min	min	min	min	min	min	min
GP240GH	1.0619	+ N	0,2 %	210	175	145	135	130	125	-	-
GP240GH	1.0619	+ QT	0,2 %	210	175	145	135	130	125	-	-
GP280GH	1.0625	+ N	0,2 %	250	220	190	170	160	150	-	-
GP280GH	1.0625	+QT	0,2 %	250	220	190	160	160	150	-	-
G20Mo5	1.6220	+ QT	0,2 %	-	190	165	155	150	145	135	-
G17CrMo5–5	1.7357	+ QT	0,2 %	-	250	230	215	200	190	175	160
G12MoCrV5–2	1.7720	+ QT	0,2 %	264	244	230	-	214	-	194	144
G17CrMoV5–10	1.7706	+ QT	0,2 %	-	385	365	350	335	320	300	260
G17CrMo9–10	1.7379	+ QT	0,2 %	-	355	345	330	315	305	280	240
GX15CrMo5	1.7365	+ QT	0,2 %	-	390	380	-	370	-	305	250
GX15CrMo9–1	1.7376	+ QT	0,2 %	-	375	355	345	320	295	265	-
GX23CrMoV12–1	1.4331	+QT	0,2 %	-	450	430	410	390	370	340	290

[a] Austenitic-ferritic steel grades are not recommended in applications above 250°C.

[b] 1 MPa = 1 N/mm2.

Table 5 *(continued)*

Grade designation		Type of heat treatment	R_p at elevated temperature °C (MPa[c])							
Name	No.		R_p	100 °C min	200 °C min	300 °C min	350 °C min	400 °C min	450 °C min	500 °C min	550 °C min
GX4CrNi13–4	1.4317	+QT	0,2 %	515	485	455	440	-	-	-	-
GX4CrNiMo16–5-1	1.4405	+QT	0,2 %	515	485	455	-	-	-	-	-
GX2CrNiN18–10	1.4487	+ AT	1 %	165	130	110	100	-	-	-	-
GX5CrNi19–10	1.4308	+ AT	1 %	160	125	110	-	-	-	-	-
GX5CrNiNb19–11	1.4552	+ AT	1 %	165	145	130	-	120	-	110	100
GX2CrNiMoN19–11–2	1.4490	+ AT	1 %	175	145	115	-	105	-	-	-
GX5CrNiMo19–11–2	1.4408	+ AT	1 %	170	135	115	-	105	-	-	-
GX6CrNiMoNb19–11–2	1.4581	+ AT	1 %	185	160	145	-	130	-	120	115
GX2CrNiMoN22–5-3[a]	1.4470	+ AT	0,2 %	330	280	-	-	-	-	-	-
GX2CrNiMoCuN26–5-3–3[a]	1.4451	+ AT	0,2 %	390	330	-	-	-	-	-	-
GX2CrNiMoN26–7-4[a]	1.4469	+ AT	0,2 %	390	330	-	-	-	-	-	-
GX2NiCrMo28–20–2	1.4458	+ AT	1 %	165	135	120	-	110	-	-	-

a Austenitic-ferritic steel grades are not recommended in applications above 250°C.

b 1 MPa = 1 N/mm^2.

Table 6 — Heat treatment conditions

Grade designation		Type of heat treatment [a]	Heat treatment°C [b]	
Name	Number		Normalizing (+N) or Quenching (+Q) or Solution Annealing (+AT) air or liquid	Tempering (+T)
GP240GH[c]	1.0619	+N [d]	900 – 980	-
GP240GH[c]	1.0619	+QT	900 – 980	600 – 700
GP280GH[c]	1.0625	+N [d]	900 – 980	-
GP280GH[c]	1.0625	+QT	900– 980	600 – 700
G17Mn5	1.1131	+QT	890 – 980	600 – 700
G20Mn5[c]	1.6220	+N [d]	900 – 980	-
G20Mn5[c]	1.6220	+QT	900 – 980	610 – 660
G18Mo5	1.5422	+QT	900 – 980	600 – 700
G20Mo5	1.5419	+QT	920 – 980	650 – 730
G17CrMo5–5	1.7357	+QT	920 – 960	680 – 730
G17CrMo9–10	1.7379	+QT	930 – 970	680 – 740
G12MoCrV5–2	1.7720	+QT	950 – 1000	680 – 720
G17CrMoV5–10	1.7706	+QT	920 – 960	680 – 740
G25NiCrMo3[c]	1.6553	+QT1	970 – 960	600 – 700
G25NiCrMo3[c]	1.6553	+QT2	870 – 960	600 – 680

a The type of heat treatment is mandatory.

b The temperatures are for information only.

c According to the required tensile properties the heat treatment symbol is added to the designation.

d Tempering is permitted.

e This grade requires double tempering. The second temper shall not be higher than the first temper.

f For improving the corrosion resistance, a special stabilization heat treatment in the range of 600 °C to 650 °C for GX6CrNiNb19–10 and 550 °C to 600 °C for GX6CrNiMoNb19–11–2 may be agreed.

g After solution annealing castings may be cooled down to 1 040°C to 1 010°C prior to water quenching.

Table 6 *(continued)*

Grade designation		Type of heat treatment [a]	Heat treatment°C [b]	
Name	Number		Normalizing (+N) or Quenching (+Q) or Solution Annealing (+AT) air or liquid	Tempering (+T)
G25NiCrMo6[c]	1.6554	+QT1	850 – 920	600 – 650
G25NiCrMo6[c]	1.6554	+QT2	850 – 920	600 – 650
G17NiCrMo13–6	1.6781	+QT	890 – 930	600 – 640
G9Ni10	1.5636	+QT	830 – 890	600 – 650
G9Ni14	1.5638	+QT	820 – 900	590 – 640
GX15CrMo5	1.7365	+QT	930 – 990	680 – 730
GX10CrMoV9–1	1.7367	+NT	1040 - 1080	730 - 800
GX15CrMo9–1	1.7378	+QT	960 – 1020	680 – 730
GX8CrNi12–1[c]	1.4107	+QT1	1000 – 1060	680 – 730
GX8CrNi12–1[c]	1.4107	+QT2	1000 – 1060	600 – 680
GX23CrMoV12–1	1.4931	+QT	1030 – 1080	700 – 750
GX3CrNi13–4[e]	1.5982	+QT	1000 – 1050	670 – 690
				+590 – 620
GX4CrNi13–4	1.4317	+QT	1000 – 1050	590 – 620
GX4CrNiMo16–5-1	1.4405	+QT	1020 – 1070	580 – 630
GX2CrNiN19–11	1.4487	+AT	1050 – 1150	-
GX5CrNi19–9	1.4308	+AT	1050 – 1150	-
GX6CrNiNb19–10[f]	1.4552	+AT	1050 – 1150	-
GX2CrNiMoN19–11–2	1.4490	+AT	1080 – 1150	-
GX5CrNiMo19–11–2[f]	1.4408	+AT	1080 – 1150	-
GX6CrNiMoNb19–11–2	1.4581	+AT	1080 – 1150	-
GX2CrNiMoN22–5-3[g]	1.4470	+AT	1120 – 1150	-
GX2CrNiMoCuN26–5-3–3[g]	1.4451	+AT	1120 – 1150	-
GX2CrNiMoN26–7-4[g]	1.4469	+AT	1140 – 1180	-
GX2NiCrMo28–20–2	1.4458	+AT	1100 - 1180	-

[a] The type of heat treatment is mandatory.

[b] The temperatures are for information only.

[c] According to the required tensile properties the heat treatment symbol is added to the designation.

[d] Tempering is permitted.

[e] This grade requires double tempering. The second temper shall not be higher than the first temper.

[f] For improving the corrosion resistance, a special stabilization heat treatment in the range of 600 °C to 650 °C for GX6CrNiNb19–10 and 550 °C to 600 °C for GX6CrNiMoNb19–11–2 may be agreed.

[g] After solution annealing castings may be cooled down to 1 040°C to 1 010°C prior to water quenching.

Annex A
(normative)

Supplementary requirements

A.1 Agreed manufacturing procedure

A.2 Reporting of the steel making process

A.3 Chemical analysis for residual elements

A.4 Details of the heat treatment

A.5 Mass and tolerance on mass

A.6 Prior agreement to major finishing welds

A.7 Weld maps

A.8 Test blocks

A.8.1 Test blocks representative of the castings

The maximum ruling wall thickness shall be indicated by the purchaser at the time of the enquiry and order.

The mechanical properties reported in the Tables 2, 3, 4 and 5 shall apply up to the maximum ruling wall thickness given in Table A1.

The test block thickness shall be the maximum ruling wall thickness up to 150 mm.

Test blocks greater than 150 mm can be used if agreed to by purchaser and manufacturer at the time of enquiry and order.

When the ruling thickness exceeds the value given in the table lower mechanical properties can be agreed at the time of the enquiry and order.

Table A.1 — Maximum ruling wall thickness

Grade designation		Maximum ruling wall thickness mm
Name	Number	
GP240GH	1.0619	100
GP280GH	1.0625	100
G17Mn5	1.1131	50
G20Mn5 +QT	1.6220	100
G18Mo5	1.5422	100
G20Mo5	1.5419	100
G17CrMo5–5	1.7357	100
G12CrMoV5–2	1.7720	100
G17CrMoV5–10	1.7706	150
G17CrMo9–10	1.7379	150
G17NiCrMo13–6	1.6781	200
GX15CrMo5	1.7365	150
GX10CrMoV9–1	1.7367	—
GX8CrNi12–1	1.4107	300
GX23CrMoV12–1	1.4931	150
GX3CrNi13–4	1.6982	300
GX4CrNi13–4	1.4317	300
GX4CrNiMo16–5-1	1.4405	300
GX2CrNiN19–11	1.4487	150
GX5CrNi19–9	1.4308	150
GX6CrNiNb19–10	1.4552	150
GX2CrNiMoN19–11–2	1.4490	150
GX5CrNiMo19–11–2	1.4408	150
GX6CrNiMoNb19–11–2	1.4581	150
GX2CrNiMoN22–5-3	1.4470	150
GX2CrNiMoCuN26–5-3–3	1.4451	150
GX2CrNiMoN26–7-4	1.4469	150
GX2NiCrMo28–20–2	1.4458	150

A.8.1.1 Test block t × t

A.8.1.2 Test block $t \times 3t \times 3t$

A.8.2 Test blocks attached to casting

A.9 Intergranular corrosion test

A.10 Pressure tightness

A.11 Ferrite determination in austenitic and austenitic-ferritic steels in accordance with ISO 13520

A.12 Verification of impact properties at room temperature

A.13 Verification of impact properties at low temperature

A.14 Verification of tensile properties at elevated temperature

Annex B
(informative)

Welding conditions

Table B.1 — Welding conditions

Grade designation		Preheat temperature [a]	Max. interpass temperature	Post heat treatment
Name	Number	°C	°C	°C
GP240GH	1.0619	20 to 150	350	Not necessary
GP280GH	1.0625	20 to 150	350	Not necessary
G17Mn5	1.1131	20 to 150	350	Not necessary
G20Mn5	1.6220	20 to 150	350	Not 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
G12MoCrV5–2	1.7720	200 to 300	400	> 680
G17CrMoV5–10	1.7706	200 to 300	400	> 680
G25NiCrMo6	1.6554	150 to 250	350	b
G17CrMo9–10	1.7379	150 to 250	350	> 680
G17NiCrMo13–6	1.6781	20 to 200	350	> 580
G9Ni10	1.5636	20 to 150	350	> 570
G9Ni14	1.5638	20 to 200	300	> 560
GX15CrMo5	1.7365	150 to 250	350	650
GX10CrMoV9–1	1.7367			
GX15CrMo9–1	1.7376	200 to 300	350	680
GX8CrNi12–1	1.4107	100 to 200	350	Same as normal tempering temperature
GX4CrNiMo16–5-1	1.4405	Not necessary	200	Same as normal tempering temperature
GX3CrNi13–4	1.6982	20 to 200	c	c
GX4CrNi13–4	1.4317	100 to 200	300	Same as normal tempering temperature
GX23CrMoV12–1	1.4931	20 to 450	450	> 680 °C after cooling under 80 °C to 130 °C
GX2CrNiN19–11	1.4487			d
GX5CrNi19–9	1.4308			d
GX6CrNiNb19–10	1.4552			d
GX2CrNiMoN19–11–2	1.4490	Not necessary	c	d
GX5CrNiMo19–11–2	1.4408	Not necessary		d
GX6CrNiMoNb19–11–2	1.4581	Not necessary		d
GX2CrNiMoN22–5-3	1.4470	20 to 100	250	d
GX2CrNiMoCuN26–5-3–3	1.4451	20 to 100	250	d
GX2CrNiMoN26–7-4	1.4469	20 to 100	250	d
GX2NiCrMo28–20–2	1.4458	20 to 100	150	d

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

[b] The post heat treatment shall be at least 20 °C but no more than 50 °C below the tempering temperature.

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

[d] Depending on the corrosion resistance and mechanical property requirements, +AT may be necessary

Annex C
(informative)

Creep properties