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GB/T 13296—2023
Replace GB/T 13296—2013

Seamless stainless steel tubes for boiler and heat exchanger

锅炉、热交换器用不锈钢无缝钢管

(*English Translation*)

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Foreword

SAC/TC 183 is in charge of this English translation. In case of any doubt about the contents of English translation, the Chinese original shall be considered authoritative.

This standard is drafted in accordance with the rules given in GB/T 1.1—2020, *Directives for standardization—Part 1: Rules for the structure and drafting of standardizing documents*.

This standard replaces GB/T 13296—2013, *Seamless stainless steel tubes for boiler and heat exchanger* in whole. Except the structural adjustments and editorial changes, the following technical deviations have been made with respect to the GB/T 13296—2013.

a) Add terms and definitions(see Chapter 3);

b) Revise the calculation method of delivered theoretical mass for tubes with minimum wall thickness(see 6.6,5.6 of GB/T 13296—2013);

c) Revise S content in chemical composition(see Table 3,Table 3 of GB/T 13296—2013);

d) Revise Ti content of Grades 06Cr17Ni12Mo2Ti, 06Cr18Ni11Ti and 07Cr19Ni11Ti(see Table 3, Table 3 of GB/T 13296—2013);

e) Add Grades 015Cr20Ni18Mo6CuN, 022Cr21Ni25Mo7N and their relative requirements (see Table 3 to Table 5);

f) Revise the organization type of Grade 06Cr13 to ferritic type (see Table 3 to Table 5, Table 3 to Table 5 of GB/T 13296—2013);

g) Add the requirements of stabilization heat treatment (see 7.3.2);

h) Revise the heat treatment processes of Grade 07Cr17Ni12Mo2(see Table 4, Table 4 of GB/T 13296—2013);

i) Revise the hardness requirements of austenitic steel tubes(see Table 5, Table 5 of GB/T 13296—2013);

j) Revise the calculated values of allowable stresses for hydrostatic test(see 7.5.1, 6.5.1 of GB/T 13296—2013);

k) Revise the acceptance level of eddy current test(see 7.5.2, 6.5.2 of GB/T 13296—2013);

l） Revise the requirements of drift expanding（see 7.6.2，6.6.2 of GB/T 13296—2013）；

m） Revise the proof strength at elevated temperature of Grades 07Cr19Ni10，07Cr19Ni11Ti and 07Cr18Ni11Nb（see Table A.1，Table A.1 of GB/T 13296—2013）；

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

This standard was proposed by China Iron and Steel Association.

This standard was prepared by Technical Committee on Steel of Standardization Administration of China（SAC/TC 183）.

The previous editions of this standard are as follows：

—GB 13296—1991，GB 13296—2007，GB/T 13296—2013.

Seamless stainless steel tubes for boiler and heat exchanger

1 Scope

This document specifies classification, designations, ordering information, dimensions, shapes, masses and permissible variations, technical requirements, test methods, inspection rules, packaging, marking and quality certification of seamless stainless steel tubes for boiler and heat exchanger.

This document is applicable to seamless stainless steel tubes for boiler and heat exchanger (hereinafter referred to as tubes).

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.

GB/T 222, *Permissible tolerances for chemical composition of steel products*

GB/T 223.11, *Iron, steel and alloy—Determination of chromium content—Visual titration or potentiometric titration method*

GB/T 223.18, *Methods for chemical analysis of iron, steel and alloy—The sodium thiosulfate separation iodimetric method for the determination of copper content*

GB/T 223.19, *Methods for chemical analysis of iron, steel and alloy—The neocuproine-chloroform extraction photometric method for the determination of copper content*

GB/T 223.23, *Iron, steel and alloy—Determination of nickel content—The dimethylglyoxime spectrophotometric method*

GB/T 223.25, *Methods for chemical analysis of iron, steel and alloy—The dimethylglyoxime gravimetric method for the determination of nickel content*

GB/T 223.26, *Iron, steel and alloy—Determination of molybdenum content—The thiocyanate spectrophotometric method*

GB/T 223.28，*Methods for chemical analysis of iron，steel and alloy—The α-benzoinoxime gravimetric method for the determination of molybdenum content*

GB/T 223.36，*Methods for chemical analysis of iron，steel and alloy—The neutral titration method for the determination of nitrogen content after distillation separation*

GB/T 223.37，*Iron，steel and alloy—Determination of nitrogen content—Indophenol blue spectrophotometric method after distillation separation*

GB/T 223.40，*Iron，steel and alloy—Determination of niobium content by the sulphochlorophenol S spectrophotometric method*

GB/T 223.59，*Iron，steel and alloy—Determination of phosphorus content—Bismuth phosphomolybdate blue spectrophotometric method and antimony phosphomolybdate blue spectrophotometric method*

GB/T 223.60，*Methods for chemical analysis of iron，steel and alloy—The perchloric acid dehydration gravimetric method for the determination of silicon content*

GB/T 223.63，*Methods for chemical analysis of iron，steel and alloy—The sodium（potassium）periodate photometric method for the determination of manganese content*

GB/T 223.84，*Steel and iron—Determination of titanium content—Diantipyrylmethane spectrophotometric method*

GB/T 223.85，*Steel and iron—Determination of sulfur content—Infrared absorption method after combustion in an induction furnace*

GB/T 223.86，*Steel and iron—Determination of total carbon content—Infrared absorption method after combustion in an induction furnace*

GB/T 228.1，*Metallic materials—Tensile testing—Part 1：Method of test at room temperature*

GB/T 228.2，*Metallic materials—Tensile testing—Part 2：Method of test at elevated temperature*

GB/T 230.1，*Metallic materials—Rockwell hardness test—Part 1：Test method*（A，B，C，D，E，F，G，H，K，N，S rulers）

GB/T 231.1，*Metallic materials—Brinell hardness test—Part 1：Test method*

GB/T 241，*Metal materials—Tube—Hydrostatic pressure test*

GB/T 242，*Metal materials—Tube—Drift-expanding test*

GB/T 246，*Metallic materials—Tube—Flattening test*

GB/T 2102，*Acceptance，packing，marking and quality certification of steel pipe*

GB/T 2975，*Steel and steel products—Location and preparation of samples and test pieces for mechanical testing*

GB/T 4334，*Corrosion of metals and alloys - Test methods for intergranular corrosion of stainless steels*

GB/T 4340.1，*Metallic materials—Vickers hardness test—Part 1：Test method*

GB/T 5777—2019，*Automated full peripheral ultrasonic testing of seamless and welded（except submerged arc-welded）steel tubes for the detection of longitudinal and/or transverse imperfections*

GB/T 6394，*Determination of estimating the average grain size of metal*

GB/T 7735—2016，*Automated eddy current testing of seamless and welded（except submerged arc-welded）steel tubes for the detection of imperfections*

GB/T 11170，*Stainless steel—Determination of multi-element contents—Spark discharge atomic emission spectrometric method（Routine method）*

GB/T 17395，*Dimensions，shapes，masses and tolerances of seamless steel tube*

GB/T 20066，*Steel and iron—Sampling and preparation of samples for the determination of chemical composition*

GB/T 20123，*Steel and iron—Determination of total carbon and sulfur content—Infrared absorption method after combustion in an induction furnace（routine method）*

GB/T 20124，*Steel and iron—Determination of nitrogen content—Thermal conductimetric method after fusion in a current of inert gas（routine method）*

GB/T 30062，*Terminology of steel pipes and tubes*

YB/T 4395，*Steel—Determination of molybdenum，niobium and tungsten contents—Inductively coupled plasma atomic emission spectrometric method*

YB/T 4396，*Stainless steel—Determination of multi-element contents—Inductively coupled plasma atomic emission spectrometric method*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in GB/T 30062 apply.

4 Classification and symbols

4.1 Tubes are classified as follows based on the manufacturing method:

—Hot rolled (extruded) steel tube, W-H;

—Cold drawn (rolled) steel tube, W-C.

4.2 The following symbols are applicable to this document:

D nominal outside diameter (in millimeters);

S nominal wall thickness (in millimeters);

S_{min} minimum wall thickness (in millimeters);

S_C average wall thickness (the average value of the maximum value and the minimum value of wall thickness calculated from the minimum wall thickness and its tolerance, in millimeters).

5 Ordering information

The purchase contract or order according to this document shall include, but not limit to the following information:

a) this document number;

b) name of product;

c) steel grade;

d) dimensions (OD × WT, in millimeters);

e) ordering quantity (total mass or total length or total pieces);

f) manufacturing method;

g） other special requirements.

6 Dimensions，shapes，masses and tolerances

6.1 Outside diameter and wall thickness

6.1.1 Tubes shall be delivered by nominal outside diameter（D）and minimum wall thickness（S_{min}）unless otherwise specified in the contract. If required by the purchaser and agreed between the supplier and purchaser，tubes may be delivered by nominal outside diameter and nominal wall thickness（S）.

6.1.2 The dimensions of tubes shall comply with the requirements specified in GB/T 17395. If required by the purchaser and agreed between the supplier and purchaser，tubes with dimensions not specified in GB/T 17395 may be supplied.

6.1.3 For the tubes delivered by nominal outside diameter and minimum wall thickness，the permissible variations in the nominal outside diameter and minimum wall thickness shall comply with the requirements specified in Table 1. For the tubes delivered by nominal outside diameter and nominal wall thickness，the permissible variations in the nominal outside diameter shall comply with the requirements specified in Table 1，and the permissible variations in nominal wall thickness shall comply with the requirements specified in Table 2.

6.1.4 If required by the purchaser，agreed between the supplier and purchaser，and specified in the contract，tubes with the permissible dimensional variations not listed in Tables 1 and 2 may be supplied.

Table 1—Permissible variations in nominal outside diameter and minimum wall thickness

In millimeters

Classification and symbols	Nominal dimensions		Permissible variations
Hot rolled（extruded）steel tube W-H	Nominal outside diameter（D）	≤140	±1.25%D
		＞140	±1%D
	Minimum wall thickness（S_{min}）	≤4.0	+0.90 0
		＞4.0	+25%S 0
Cold drawn（rolled）steel tube W-C	Nominal outside diameter（D）	≤25	±0.10
		＞25 to 40	±0.15
		＞40 to 50	±0.20
		＞50 to 65	±0.25
		＞65 to 75	±0.30
		＞75 to 100	±0.38
		＞100 to 159	+0.38 −0.64
		＞159	±0.5%D

Table 1（*continued*）

In millimeters

Classification and symbols	Nominal dimensions		Permissible variations
Cold drawn（rolled）steel tube W-C	Minimum wall thickness（S_{min}）	$D \leqslant 38$	$^{+20\%S}_{0}$
		$D > 38$	$^{+22\%S}_{0}$

Table 2—Permissible variations in nominal wall thickness

In millimeters

Classification and symbols	Range of wall thickness		Permissible variations
Hot rolled（extruded）steel tube W-H	Nominal wall thickness（S）	⩽4.0	±0.45
		>4.0	+12.5%S −10%S
Cold drawn（rolled）steel tube W-C	Nominal wall thickness（S）	D⩽38	±10%S
		D>38	±11%S

6.2 Length

6.2.1 Random length

The random length of tube is 2 000 mm to 12 000 mm. If required by the purchaser, agreed between the supplier and purchaser, and specified in the contract, the tube longer than 12 000 mm may be delivered.

6.2.2 Cut-length and multiple lengths

If required by the purchaser, agreed between the supplier and purchaser, and specified in the contract, tube may be supplied in cut-length or multiple lengths. The permissible variations in the cut-length is $^{+10}_{0}$ mm. Each multiple length shall have the cutting allowance reserved 5 mm to 10 mm.

6.3 Straightness

The deviation from straightness per meter of hot rolled（extruded）tube shall not exceed 2.0 mm. The deviation from straightness per meter of cold drawn（rolled）tube shall not exceed 1.5 mm. The deviation from straightness of full length shall not exceed 0.15% of the tube length.

6.4 Out-of-roundness and unevenness in wall thickness

The out-of-roundness and unevenness in wall thickness of tube shall not exceed 80% of the out-

side diameter tolerance and the wall thickness tolerance respectively.

6.5 End shape

Both ends shall be perpendicular to the axis of tube, and all burrs at the ends shall be removed.

6.6 Masses

6.6.1 The tube shall be delivered by actual mass. If required by the purchaser, agreed between the supplier and purchaser, and specified in the contract, the tube may also be delivered by theoretical mass.

6.6.2 For tubes with nominal wall thickness delivered, the theoretical mass per meter of the tube shall be calculated according to Formula (1).

$$W=\frac{\pi}{1\,000}\rho S(D-S) \tag{1}$$

where

W is the theoretical mass of tubes, in kilograms per meter (kg/m);

π is 3.1416;

ρ is the density of steel, in kilograms per cubic decimeter (kg/dm^3), density of the steel defined as Table 4;

S is the nominal wall thickness, in millimeters (mm);

D is the nominal outside diameter, in millimeters (mm).

6.6.3 For tubes with minimum wall thickness delivered, the theoretical mass per meter of tube shall be calculated based on the average wall thickness (S_c).

7 Technical requirements

7.1 Steel grades and chemical composition

7.1.1 The steel grades and chemical composition (heat analysis) shall comply with the requirements specified in Table 3.

7.1.2 The permissible deviation of the product analysis shall comply with the requirements speci-

fied in GB/T 222.

7.2 Manufacturing method

7.2.1 Steel-making process

The steel shall be made by electric arc furnace and external refining, or converter and external refining, or electroslag remelting. If agreed between the supplier and the purchaser, and specified in the contract, other steel-making processes may also be adopted.

7.2.2 Tube production process

The tubes shall be manufactured by the process of hot rolling (extrusion) or cold drawing (rolling).

7.3 Delivery conditions

7.3.1 The tubes shall be delivered in the condition of heat treatment and pickling. The tubes grinded and bored integrally or heat-treated in a protective atmosphere may be delivered without pickling.

7.3.2 If required by the purchaser, agreed between the supplier and purchaser, and specified in the contract, the tubes containing stabilizing elements(Ti or Nb) may be subjected to the stabilization heat treatment subsequent to solution heat treatment, the stabilization heat treatment procedure shall be agreed by the supplier and the purchaser.

7.4 Mechanical properties

7.4.1 For tubes delivered in heat treatment condition, the longitudinal tensile properties at room temperature shall comply with the requirements specified in table 4.

7.4.2 If required by the purchaser, agreed between the supplier and the purchaser, and specified in the contract, for the tubes with wall thickness greater than 1.7 mm, Vickers hardness or Brinell hardness or Rockwell hardness may be tested, the test value shall comply with the requirements specified in Table 5.

7.4.3 If required by the purchaser, agreed between the supplier and the purchaser, and specified in the contract, the tensile test at elevated temperature for tubes with grades 07Cr19Ni10、07Cr19Ni11Ti and 07Cr18Ni11Nb may be adopted, and the test value of the proof strength at elevated temperature ($R_{p0.2}$) shall comply with the requirements specified in Annex A. If the test value of tensile strength at elevated temperature(R_m)required to provide by purchaser, the value shall be agreed between the supplier and the purchaser.

7.4.4 Recommended data of 100 000 h creep rupture strength of the tubes with grades 07Cr19Ni10、07Cr19Ni11Ti and 07Cr18Ni11Nb are given in Annex B.

Table 3—Steel grades and chemical composition

Steel type	No	ISC	Designation	Chemical composition(mass fraction)/%										
				C	Si	Mn	P	S	Ni	Cr	Mo	Cu	N	Other elements
Austenitic type	1	S30210	12Cr18Ni9	0.15	1.00	2.00	0.035	0.015	8.00 to 10.00	17.00 to 19.00	—	—	0.10	—
	2	S30408	06Cr19Ni10	0.08	1.00	2.00	0.035	0.015	8.00 to 11.00	18.00 to 20.00	—	—	—	—
	3	S30403	022Cr19Ni10	0.030	1.00	2.00	0.035	0.015	8.00 to 12.00	18.00 to 20.00	—	—	—	—
	4	S30409	07Cr19Ni10	0.04 to 0.10	1.00	2.00	0.035	0.015	8.00 to 11.00	18.00 to 20.00	—	—	—	—
	5	S30458	06Cr19Ni10N	0.08	1.00	2.00	0.035	0.015	8.00 to 11.00	18.00 to 20.00	—	—	0.10 to 0.16	—
	6	S30453	022Cr19Ni10N	0.030	1.00	2.00	0.035	0.015	8.00 to 11.00	18.00 to 20.00	—	—	0.10 to 0.16	—
	7	S30920	16Cr23Ni13	0.20	1.00	2.00	0.035	0.015	12.00 to 15.00	22.00 to 24.00	—	—	—	—
	8	S30908	06Cr23Ni13	0.08	1.00	2.00	0.035	0.015	12.00 to 15.00	22.00 to 24.00	—	—	—	—
	9	S31020	20Cr25Ni20	0.25	1.50	2.00	0.035	0.015	19.00 to 22.00	24.00 to 26.00	—	—	—	—
	10	S31008	06Cr25Ni20	0.08	1.50	2.00	0.035	0.015	19.00 to 22.00	24.00 to 26.00	—	—	—	—
	11	S31608	06Cr17Ni12Mo2	0.08	1.00	2.00	0.035	0.015	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—	—	—
	12	S31603	022Cr17Ni12Mo2	0.030	1.00	2.00	0.035	0.015	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—	—	—
	13	S31609	07Cr17Ni12Mo2	0.04 to 0.10	1.00	2.00	0.035	0.015	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—	—	—

Table 3 (*continued*)

Steel type	No	ISC	Designation	Chemical composition(mass fraction)/%										
				C	Si	Mn	P	S	Ni	Cr	Mo	Cu	N	Other elements
Austenitic type	14	S31668	06Cr17Ni12Mo2Ti	0.08	1.00	2.00	0.035	0.015	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—	—	Ti:5(C+N)-0.70
	15	S31658	06Cr17Ni12Mo2N	0.08	1.00	2.00	0.035	0.015	10.00 to 13.00	16.00 to 18.00	2.00 to 3.00	—	0.10 to 0.16	—
	16	S31653	022Cr17Ni12Mo2N	0.030	1.00	2.00	0.035	0.015	10.00 to 13.00	16.00 to 18.00	2.00 to 3.00	—	0.10 to 0.16	—
	17	S31688	06Cr18Ni12Mo2Cu2	0.08	1.00	2.00	0.035	0.015	10.00 to 14.00	17.00 to 19.00	1.20 to 2.75	1.00 to 2.50	—	—
	18	S31683	022Cr18Ni14Mo2Cu2	0.030	1.00	2.00	0.035	0.015	12.00 to 16.00	17.00 to 19.00	1.20 to 2.75	1.00 to 2.50	—	—
	19	S39042	015Cr21Ni26Mo5Cu2	0.020	1.00	2.00	0.035	0.015	24.00 to 26.00	19.00 to 21.00	4.00 to 5.00	1.20 to 2.00	0.10	—
	20	S31708	06Cr19Ni13Mo3	0.08	1.00	2.00	0.035	0.015	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—	—	—
	21	S31703	022Cr19Ni13Mo3	0.030	1.00	2.00	0.035	0.015	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—	—	—
	22	S32168	06Cr18Ni11Ti	0.08	1.00	2.00	0.035	0.015	9.00 to 12.00	17.00 to 19.00	—	—	—	Ti:5(C+N)-0.70
	23	S32169	07Cr19Ni11Ti	0.04 to 0.10	0.75	2.00	0.035	0.015	9.00 to 13.00	17.00 to 20.00	—	—	—	Ti:4(C+N)-0.70
	24	S34778	06Cr18Ni11Nb	0.08	1.00	2.00	0.035	0.015	9.00 to 12.00	17.00 to 19.00	—	—	—	Nb:10C-1.10
	25	S34779	07Cr18Ni11Nb	0.04 to 0.10	1.00	2.00	0.035	0.015	9.00 to 12.00	17.00 to 19.00	—	—	—	Nb:8C-1.10
	26	S38148	06Cr18Ni13Si4	0.08	3.00 to 5.00	2.0	0.035	0.015	11.50 to 15.00	15.00 to 20.00	—	—	—	—

Table 3 （*continued*）

Steel type	No	ISC	Designation	Chemical composition（mass fraction）/%										
				C	Si	Mn	P	S	Ni	Cr	Mo	Cu	N	Other elements
Austenitic type	27	S31252	015Cr20Ni18Mo6CuN	0.020	0.80	1.00	0.030	0.010	17.50 to 18.50	19.50 to 20.50	6.00 to 6.50	0.50 to 1.00	0.18 to 0.22	—
	28	S38367	022Cr21Ni25Mo7N	0.030	1.00	2.00	0.035	0.015	23.50 to 25.50	20.00 to 22.00	6.00 to 7.00	0.75	0.18 to 0.25	—
Ferritic type	29	S11710	10Cr17	0.12	1.00	1.00	0.030	0.015	0.60	16.00 to 18.00	—	—	—	—
	30	S12791	008Cr27Mo[a]	0.010	0.40	0.40	0.030	0.015	—	25.00 to 27.50	0.75 to 1.50	—	0.015	—
	31	S11306	06Cr13	0.06	1.00	1.00	0.035	0.015	0.60	11.50 to 13.50	—	—	—	—

NOTE The chemical composition in this table is a maximum value unless a range is indicated.

[a] 0.50%max Ni and 0.20% max Cu are permitted，but Ni + Cu shall be 0.50% max.

Table 4—Heat treatment process，tensile properties at room temperature and density

Steel type	No	ISC	Designation	Heat treatment process	Mechanical properties			Density ρ kg/dm^3
					Tensile Strength R_m MPa	Proof Strength $R_{p0.2}$ MPa	Percentage elongation after fracture A %	
					Min.			
Austenitic type	1	S30210	12Cr18Ni9	1 010 ℃ to 1 150 ℃，rapid cooling	520	205	35	7.93
	2	S30408	06Cr19Ni10	1 010 ℃ to 1 150 ℃，rapid cooling	520	205	35	7.93
	3	S30403	022Cr19Ni10	1 010 ℃ to 1 150 ℃，rapid cooling	480	175	35	7.90
	4	S30409	07Cr19Ni10	1 010 ℃ to 1 150 ℃，rapid cooling	520	205	35	7.90
	5	S30458	06Cr19Ni10N	1 010 ℃ to 1 150 ℃，rapid cooling	550	240	35	7.93
	6	S30453	022Cr19Ni10N	1 010 ℃ to 1 150 ℃，rapid cooling	515	205	35	7.93
	7	S30920	16Cr23Ni13	1 030 ℃ to 1 150 ℃，rapid cooling	520	205	35	7.98
	8	S30908	06Cr23Ni13	1 030 ℃ to 1 150 ℃，rapid cooling	520	205	35	7.98
	9	S31020	20Cr25Ni20	1 030 ℃ to 1 180 ℃，rapid cooling	520	205	35	7.98
	10	S31008	06Cr25Ni20	1 030 ℃ to 1 180 ℃，rapid cooling	520	205	35	7.98
	11	S31608	06Cr17Ni12Mo2	1 010 ℃ to 1 150 ℃，rapid cooling	520	205	35	8.00
	12	S31603	022Cr17Ni12Mo2	1 010 ℃ to 1 150 ℃，rapid cooling	480	175	40	8.00
	13	S31609	07Cr17Ni12Mo2	1 040 ℃ to 1 150 ℃，rapid cooling	520	205	35	8.00
	14	S31668	06Cr17Ni12Mo2Ti	1 000 ℃ to 1 100 ℃，rapid cooling	530	205	35	7.90
	15	S31658	06Cr17Ni12Mo2N	1 010 ℃ to 1 150 ℃，rapid cooling	550	240	35	8.00
	16	S31653	022Cr17Ni12Mo2N	1 010 ℃ to 1 150 ℃，rapid cooling	515	205	35	8.04
	17	S31688	06Cr18Ni12Mo2Cu2	1 010 ℃ to 1 150 ℃，rapid cooling	520	205	35	7.96
	18	S31683	022Cr18Ni14Mo2Cu2	1 010 ℃ to 1 150 ℃，rapid cooling	480	180	35	7.96

Table 4 （*continued*）

Steel type	No	ISC	Designation	Heat treatment process	Mechanical properties			Density ρ kg/dm^3
					Tensile Strength R_m MPa	Proof Strength $R_{p0.2}$ MPa	Percentage elongation after fracture A %	
					Min.			
Austenitic type	19	S39042	015Cr21Ni26Mo5Cu2	1 065 ℃ to 1 150 ℃, rapid cooling	490	220	35	8.00
	20	S31708	06Cr19Ni13Mo3	1 010 ℃ to 1 150 ℃, rapid cooling	520	205	35	8.00
	21	S31703	022Cr19Ni13Mo3	1 010 ℃ to 1 150 ℃, rapid cooling	480	175	35	7.98
	22	S32168	06Cr18Ni11Ti	920 ℃ to 1 150 ℃, rapid cooling	520	205	35	8.03
	23	S32169	07Cr19Ni11Ti	Hot rolled(extruded)≥1 050 ℃, rapid cooling Cold drawn (rolled)≥1 100 ℃, rapid cooling	520	205	35	8.03
	24	S34778	06Cr18Ni11Nb	980 ℃ to 1 150 ℃, rapid cooling	520	205	35	8.03
	25	S34779	07Cr18Ni11Nb	Hot rolled(extruded)≥1 050 ℃, rapid cooling Cold drawn (rolled)≥1 100 ℃, rapid cooling	520	205	35	8.03
	26	S38148	06Cr18Ni13Si4	1 010 ℃ to 1 150 ℃, rapid cooling	520	205	35	7.75
	27	S31252	015Cr20Ni18Mo6CuN	≥1 150 ℃, rapid cooling	675	310	35	8.10
	28	S38367	022Cr21Ni25Mo7N	≥1 110 ℃, rapid cooling	690	310	30	8.06
Ferritic type	29	S11710	10Cr17	780 ℃ to 850 ℃, air cooling or slow cooling	410	245	20	7.70
	30	S12791	008Cr27Mo	900 ℃ to 1 050 ℃, rapid cooling	410	245	20	7.67
	31	S11306	06Cr13	750 ℃ air cooling or 800 ℃ to 900 ℃ slow cooling	410	210	20	7.75
The tensile strength of hot extruded tubes may be reduced 20 MPa								

Table 5—Hardness

Steel type	Designation	Hardness		
		HBW	HRB	HV
Austenitic type	06Cr18Ni13Si4	≤207	≤95	≤218
	015Cr20Ni18Mo6CuN	≤220	≤96	≤230
	022Cr21Ni25Mo7N	—	≤100	—
	Others	≤192	≤90	≤200
Ferritic type	10Cr17、06Cr13	≤183	—	—
	008Cr27Mo	≤219	—	—

7.5 Hydrostatic Test

7.5.1 Each steel tube shall be subjected to a hydrostatic test. The hydrostatic test pressure is determined by Formula (2) and the maximum test pressure is 20 MPa. The test pressure shall be held for at least 10 s. No leaks shall occur on the tube during the test.

$$P = 2SR/D \quad (2)$$

where

P is the test pressure, in MPa, rounded to the nearest 0.5 MPa for pressure below 7 MPa, and to the nearest 1 MPa for pressures 7 MPa or above;

S is the nominal wall thickness of tube or average wall thickness of tube (delivered by minimum wall thickness), in millimeters;

R is the allowable stresses, 60% of the specified minimum yield strength shown in Table 4, in MPa;

D is the nominal outside diameter of steel tube, in millimeters.

7.5.2 Hydrostatic test may be replaced with eddy current testing by supplier. For eddy current testing, the acceptance level shall comply with the requirements of E3H specified in GB/T 7735—2016.

7.6 Processing properties

7.6.1 Flattening

The flattening test shall be conducted for the tube with wall thickness 10 mm or less.

When testing, the test piece shall be pressed to the distance H between the two plates, and no cracks or breaks shall occur, and H is calculated according to Formula (3).

$$H=\frac{(1+\alpha)S}{\alpha+S/D} \tag{3}$$

where

H is the distance between two flattening plates, in millimeters;

α is the coefficient of deformation per unit length, 0.08 for austenitic type, 0.07 for others;

S is the nominal wall thickness of tube or average wall thickness of tube (delivered by minimum wall thickness), in millimeters;

D is the nominal outside diameter of tube, in millimeters.

7.6.2 Drift-expending test

Drift-expanding test shall be carried out with a 60° conical tool for the tubes with outside diameter not greater than 150 mm and wall thickness not greater than 10 mm. The percentage increase in the outside diameter of the test piece shall be 18% for austenitic type and 15% for others, no cracks or breaks shall occur on the test piece after test.

7.7 Corrosion test

7.7.1 For grades 07Cr19Ni10, 16Cr23Ni13, 20Cr25Ni20, 07Cr17Ni12Mo2, 07Cr19Ni11Ti and 07Cr18Ni11Nb, the intergranular corrosion test may not be made. For other austenitic type, the Intergranular corrosion test shall be carried out in accordance with Method E specified in GB/T 4334—2020. After testing, no tendency of intergranular corrosion shall occur on the test piece.

7.7.2 If agreed between the supplier and the purchaser, and specified in the contract, other corrosion test methods may be used.

7.8 Grain size

The grain sizes of grades 07Cr19Ni10, 07Cr17Ni12Mo2, 07Cr19Ni11Ti and 07Cr18Ni11Nb shall be No. 4 to No. 7.

7.9 Non-destructive testing

7.9.1 Each tube shall be carried out the ultrasonic testing in accordance with GB/T 5777—2019, the acceptance level of the reference notch shall be U2.

7.9.2 If required by the purchaser, agreed between the supplier and the purchaser, and specified in the contract, the tubes may be tested by other ultrasonic testing methods and acceptance level.

7.10 Surface quality

7.10.1 The inside and outside surfaces of the tube shall be free from any defect such as cracks, laps, rolling wrinkles, abscissions and scabs. These defects shall be removed completely, and the dressed areas shall blend smoothly into the contour of the tube. The actual wall thickness in the dressed area shall be not less than the permitted minimum wall thickness.

7.10.2 The permissible depth of plug scores on the inside and outside surface of the tube shall comply with the following requirements:

a) Cold drawn(rolled) tube: not deeper than 4% of the wall thickness and no larger than 0.2 mm;

b) Hot rolled(extruded) tube: not deeper than 5% of the wall thickness, and no larger than 0.4 mm.

7.10.3 Other local imperfections not exceeding the lower limit of wall thickness are permissible.

8 Test methods

8.1 The sampling of the tube for chemical composition analysis shall comply with GB/T 20066. Chemical analysis is usually conducted in accordance with GB/T 11170, GB/T 20123, GB/T 20124 or other general methods. In case of arbitration, the analysis shall be conducted according to GB/T 223.11, GB/T 223.18, GB/T 223.19, GB/T 223.23, GB/T 223.25, GB/T 223.26, GB/T 223.28, GB/T 223.36, GB/T 223.37, GB/T 223.40, GB/T 223.59, GB/T 223.60, GB/T 223.63, GB/T 223.84, GB/T 223.85, GB/T 223.86, YB/T 4395 and YB/T 4396. In case of arbitration, the analysis shall be conducted according to the requirements of the wet method analysis.

8.2 Each tube is subjected to the measurement of dimension and shape using tools that comply with the requirements for accuracy.

8.3 The internal and external surfaces of the tube shall be visually inspected individually under sufficient illumination. The depth of the straight shall be measured by the tools that comply with the requirements for accuracy.

8.4 The sampling method and test method for other inspection items of the tube shall comply with the requirements specified in Table 6.

Table 6—Test items，sampling quantity，sampling methods and test methods for the tube

No.	Test item	Sampling quantity	Sampling method	Test method
1	Chemical composition	One test piece per heat	GB/T 20066	See 8.1
2	Tensile test	One test piece from each one of two steel pipes per test unit	GB/T 2975	GB/T 228.1
3	High temperature tensile test	One test piece from each one of two steel pipes per test unit	GB/T 2975	GB/T 228.2
4	Hardness	One test piece from each one of two steel pipes per test unit	GB/T 230.1，GB/T 231.1，GB/T 4340.1	GB/T 230.1，GB/T 231.1，GB/T 4340.1
5	Hydrostatic testing	All	—	GB/T 241
6	Eddy current testing	All	—	GB/T 7735—2016
7	Flattening test	One test piece from each one of two pipes per test unit	GB/T 246	GB/T 246
8	Drift-expanding test	One test piece from each one of two pipes per test unit	GB/T 242	GB/T 242
9	Grain size	One test piece from each one of two pipes per test unit	GB/T 6394	GB/T 6394
10	Intergranular corrosion test	One test piece from each one of two pipes per test unit	GB/T 4334—2020	GB/T 4334—2020
11	Ultrasonic testing	All	—	GB/T 5777—2019

9 Inspection rules

9.1 Inspection and acceptance

The inspection and acceptance of the steel tube shall be carried out by the supplier's quality and technical supervision department.

9.2 Test unit

Tubes shall be checked and accepted according to test unit. Each test unit consists of the tubes of the same grade，same heat number，same dimension and subjected to the same heat treatment process(heat). The quantity of each test unit shall not exceed the following requirements：

a) Outside diameter is not greater than 76 mm and the wall thickness is not greater than 3 mm，400 pcs；

b) Other sizes，200 pcs.

9.3 Sampling quantity

The sampling quantity for various test items of the steel tube shall comply with the requirements in Table 6.

9.4 Re-testing and assessment rules

The rules for re-testing and assessment of the tube shall comply with the requirements in GB/T 2102.

10 Packaging，marking and quality certificate

The packaging，marking and quality certificate of the tube shall comply with the requirements in GB/T 2102.

Annex A
（normative）
Proof strength at elevated temperatures

The proof strength（$R_{p0.2}$）at elevated temperatures of grades 07Cr19Ni10、07Cr19Ni11Ti and 07Cr18Ni11Nb shall be comply with the requirements specified in Table A. 1.

Table A. 1—Proof strength at elevated temperatures

No.	ISC	Designation	Proof strength at elevated temperatures $R_{p0.2}$ MPa min										
			Temperature ℃										
			100	150	200	250	300	350	400	450	500	550	600
1	S30409	07Cr19Ni10	170	154	144	135	129	123	119	114	110	105	99
2	S32169	07Cr19Ni11Ti	184	171	160	150	142	136	132	128	126	123	120
3	S34779	07Cr18Ni11Nb	189	177	166	158	150	145	141	139	137	131	114

Annex B
（informative）
Recommended value of 100 000 h creep rupture strength

The recommended value of 100 000 h creep rupture strength for grades 07Cr19Ni10、07Cr19Ni11Ti and 07Cr18Ni11Nb is listed in Table B. 1.

Table B. 1—Recommended value of 100 000 h creep rupture strength

No.	ISC	Designation	Recommended value of 100 000 h creep rupture strength MPa															
			Temperature ℃															
			600	610	620	630	640	650	660	670	680	690	700	710	720	730	740	750
1	S30409	07Cr19Ni10	96	88	81	74	68	63	57	52	47	44	40	37	34	31	28	26
2	S32169	07Cr19Ni11Ti	89	80	72	66	61	55	50	46	41	38	35	32	29	26	24	22
3	S34779	07Cr18Ni11Nb	132	121	110	100	91	82	74	66	60	54	48	43	38	34	31	28