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Stainless steel tubes for boiler and heat exchanger

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by The Japan Iron and Steel Federation (JISF) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act. This edition replaces the previous edition (**JIS G 3463:2012**), which has been technically revised.

However, **JIS G 3463:2012** may be applied in the **JIS** mark certification based on the relevant provisions of Article 30, paragraph (1), etc. of the Industrial Standardization Act until 19 November 2020.

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It should be noted that being in conformance with this Standard may come under the use of the patent rights and other rights held by the following:

Symbol of grade	Title of invention	Patent number	Registration date of establishment of patent right
SUS821L1TB	Alloy-saving duplex stainless steel having excellent corrosion resistance and toughness in weld heat affected zone	No. 5345070	23 August 2013

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NOTE Based on Article 9 of the Supplementary Provisions to the Unfair Competition Prevention Act etc., any submission of proposal, or employment of procedures such as deliberation by the Japanese Industrial Standards Committee under the previous Industrial Standardization Act shall be deemed to have been conducted pursuant to the provision of Article 12, paragraph (1) of the revised Industrial Standardization Act.

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Stainless steel tubes for boiler and heat exchanger

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 9329-4:1997**, Edition 1, and **ISO 9330-6:1997**, Edition 1, with some modifications of the technical contents.

In addition to the specification items in the main body, the supplementary quality requirements to be applied upon agreement between the purchaser and the manufacturer, and the requirements for U-bent tubes that are applied when specified by the purchaser, are given in Annex JA and Annex JB, respectively. The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standards. A list of modifications with the explanations is given in Annex JC.

1 Scope

This Standard specifies requirements for the stainless steel tubes (hereafter referred to as tubes) used for exchanging heat between the inside and outside of the tube, such as superheater tubes of boilers, and heat exchanger tubes, condenser tubes and catalyser tubes, etc. used in chemical and petroleum industries. It is not applicable to the steel tubes for fired heater.

This Standard is generally applicable to tubes of outside diameters 15.9 mm to 139.8 mm.

NOTE The International Standards corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 9329-4:1997 *Seamless steel tubes for pressure purposes—Technical delivery conditions—Part 4: Austenitic stainless steels*

ISO 9330-6:1997 *Welded steel tubes for pressure purposes—Technical delivery conditions—Part 6: Longitudinally welded austenitic stainless steel tubes (overall evaluation: MOD)*

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

- JIS G 0320 *Standard test method for heat analysis of steel products*
- JIS G 0321 *Product analysis and its tolerance for wrought steel*
- JIS G 0404 *Steel and steel products—General technical delivery requirements*
- JIS G 0415 *Steel and steel products—Inspection documents*
- JIS G 0551 *Steels—Micrographic determination of the apparent grain size*

JIS G 0567	<i>Method of elevated temperature tensile test for steels and heat-resisting alloys</i>
JIS G 0571	<i>Method of oxalic acid etching test for stainless steels</i>
JIS G 0572	<i>Method of ferric sulfate-sulfuric acid test for stainless steel</i>
JIS G 0573	<i>Method of 65 per cent nitric acid test for stainless steels</i>
JIS G 0575	<i>Method of copper sulfate-sulfuric acid test for stainless steels</i>
JIS G 0582	<i>Automated ultrasonic examination of steel pipes and tubes</i>
JIS G 0583	<i>Automated eddy current examination of steel pipes and tubes</i>
JIS Z 2241	<i>Metallic materials—Tensile testing—Method of test at room temperature</i>
JIS Z 2245	<i>Rockwell hardness test—Test method</i>
JIS Z 8401	<i>Rounding of numbers</i>

3 Symbol of grade

Tubes shall be classified into 41 grades, and their symbols shall be as given in Table 1.

Table 1 Symbols of grade and symbols for manufacturing method

Classification	Symbol of grade	Symbol for manufacturing method		
		Tube manufacturing method	Finishing method	Marking
Austenitic series	SUS304TB, SUS304HTB, SUS304LTB, SUS309TB, SUS309STB, SUS310TB, SUS310STB, SUS312LTB, SUS315J1TB, SUS315J2TB, SUS316TB, SUS316HTB, SUS316LTB, SUS316TiTB, SUS317TB, SUS317LTB, SUS321TB, SUS321HTB, SUS347TB, SUS347HTB, SUS836LTB, SUS890LTB, SUSXM15J1TB	Seamless: S Automatic arc welded: A Laser welded: L Electric resistance welded: E	Hot-finished: H Cold-finished: C As electric resistance welded: G Weld work finished: B	As given in 14 b).
Austenitic-ferritic series	SUS821L1TB, SUS323LTB, SUS329J1TB, SUS329J3LTB, SUS329J4LTB, SUS327L1TB			
Ferritic series	SUS405TB, SUS409TB, SUS409LTB, SUS410TB, SUS410TiTB, SUS430TB, SUS430LXTB, SUS430J1LTB, SUS436LTB, SUS444TB, SUSXM8TB, SUSXM27TB			

4 Manufacturing method

The manufacturing method shall be as follows.

- Tubes shall be manufactured by a combination of the tube manufacturing method and the finishing method which are given in Table 1. Symbols indicating the manufacturing method shall be as given in Table 1. The addition of filler metal manufactured by automatic arc welding shall be left to the discretion of the manufacturer.

- b) Tubes shall be subjected to the heat treatment given in Table 2. Other heat treatments may be applied upon agreement between the purchaser and the manufacturer.
- c) Tubes shall be finished with plain ends unless otherwise specified.
- d) When tubes are manufactured by electric resistance welding, the weld beads on external and internal surfaces shall be removed to smooth the surfaces along the contour of the tube. The weld beads on internal surface may be left unremoved if so agreed between the purchaser and the manufacturer.

Table 2 Heat treatment

Classification	Symbol of grade	Heat treatment type	Heat treatment condition °C
Austenitic series ^{b)}	SUS304TB	Solution treatment	1 010 or over, rapid cooling
	SUS304HTB		1 040 or over, rapid cooling
	SUS304LTB		1 010 or over, rapid cooling
	SUS309TB SUS309STB SUS310TB SUS310STB SUS312LTB		1 030 or over, rapid cooling
	SUS315J1TB SUS315J2TB SUS316TB		1 010 or over, rapid cooling
	SUS316HTB		1 040 or over, rapid cooling
	SUS316LTB		1 010 or over, rapid cooling
	SUS316TiTB ^{a)}		920 or over, rapid cooling
	SUS317TB SUS317LTB		1 010 or over, rapid cooling
	SUS321TB ^{a)}		920 or over, rapid cooling
	SUS321HTB		Cold-finished 1 095 or over, rapid cooling Hot-finished 1 050 or over, rapid cooling
	SUS347TB ^{a)}		980 or over, rapid cooling
	SUS347HTB		Cold-finished 1 095 or over, rapid cooling Hot-finished 1 050 or over, rapid cooling
	SUS836LTB SUS890LTB		1 030 or over, rapid cooling
	SUSXM15J1TB		1 010 or over, rapid cooling
Austenitic-ferritic series	SUS821L1TB		940 or over, rapid cooling
	SUS323LTB SUS329J1TB SUS329J3LTB SUS329J4LTB		950 or over, rapid cooling
	SUS327L1TB		1 025 or over, rapid cooling

Table 2 (concluded)

Classification	Symbol of grade	Heat treatment type	Heat treatment condition °C
Ferritic series	SUS405TB SUS409TB SUS409LTB SUS410TB SUS410TiTB SUS430TB SUS430LXTB	Annealing	700 or over, air cooling or slow cooling
	SUS430J1LTB SUS436LTB		720 or over, air cooling or slow cooling
	SUS444TB SUSXM8TB SUSXM27TB		700 or over, air cooling or slow cooling
Notes ^{a)} For tubes of SUS316TiTB, SUS321TB and SUS347TB, the stabilizing heat treatment may be specified. In this case, the temperature of heat treatment shall be 850 °C to 930 °C. ^{b)} When hot-finished seamless steel tubes made of austenitic stainless steels are subjected to hot working at the temperature specified in this table and subsequent rapid cooling, the solution treatment may be omitted unless otherwise specified by the purchaser.			

5 Chemical composition

Tubes shall be tested in accordance with **12.1** and the obtained heat analysis values shall satisfy the requirements given in Table 3. When the product analysis is requested by the purchaser, the tube shall be tested in accordance with **12.1**, and the obtained product analysis values shall satisfy the requirements given in Table 3.

Table 3 Chemical composition

Unit: %

Symbol of grade	C	Si	Mn	P	S	Ni	Cr	Mo	Others ^{c)}
SUS304TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 11.00	18.00 to 20.00	— ^{b)}	—
SUS304HTB	0.04 to 0.10	0.75 max.	2.00 max.	0.040 max.	0.030 max.	8.00 to 11.00	18.00 to 20.00	— ^{b)}	—
SUS304LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	18.00 to 20.00	— ^{b)}	—
SUS309TB	0.15 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	12.00 to 15.00	22.00 to 24.00	— ^{b)}	—
SUS309STB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	12.00 to 15.00	22.00 to 24.00	— ^{b)}	—
SUS310TB	0.15 max.	1.50 max.	2.00 max.	0.040 max.	0.030 max.	19.00 to 22.00	24.00 to 26.00	— ^{b)}	—
SUS310STB	0.08 max.	1.50 max.	2.00 max.	0.040 max.	0.030 max.	19.00 to 22.00	24.00 to 26.00	— ^{b)}	—
SUS312LTB ^{a)}	0.020 max.	0.80 max.	1.00 max.	0.030 max.	0.015 max.	17.50 to 19.50	19.00 to 21.00	6.00 to 7.00	Cu: 0.50 to 1.00 N: 0.16 to 0.25
SUS315J1TB	0.08 max.	0.50 to 2.50	2.00 max.	0.045 max.	0.030 max.	8.50 to 11.50	17.00 to 20.50	0.50 to 1.50	Cu: 0.50 to 3.50
SUS315J2TB	0.08 max.	2.50 to 4.00	2.00 max.	0.045 max.	0.030 max.	11.00 to 14.00	17.00 to 20.50	0.50 to 1.50	Cu: 0.50 to 3.50
SUS316TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—
SUS316HTB	0.04 to 0.10	0.75 max.	2.00 max.	0.030 max.	0.030 max.	11.00 to 14.00	16.00 to 18.00	2.00 to 3.00	—
SUS316LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	12.00 to 16.00	16.00 to 18.00	2.00 to 3.00	—
SUS316TiTB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	10.00 to 14.00	16.00 to 18.00	2.00 to 3.00	Ti: 5 × C % min.
SUS317TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—
SUS317LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	11.00 to 15.00	18.00 to 20.00	3.00 to 4.00	—
SUS321TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	17.00 to 19.00	— ^{b)}	Ti: 5 × C % min.
SUS321HTB	0.04 to 0.10	0.75 max.	2.00 max.	0.030 max.	0.030 max.	9.00 to 13.00	17.00 to 20.00	— ^{b)}	Ti: 4 × C % to 0.60
SUS347TB	0.08 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	9.00 to 13.00	17.00 to 19.00	— ^{b)}	Nb: 10 × C % min.
SUS347HTB	0.04 to 0.10	1.00 max.	2.00 max.	0.030 max.	0.030 max.	9.00 to 13.00	17.00 to 20.00	— ^{b)}	Nb: 8 × C % to 1.00
SUS836LTB ^{a)}	0.030 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	24.00 to 26.00	19.00 to 24.00	5.00 to 7.00	N: 0.25 max.
SUS890LTB ^{a)}	0.020 max.	1.00 max.	2.00 max.	0.040 max.	0.030 max.	23.00 to 28.00	19.00 to 23.00	4.00 to 5.00	Cu: 1.00 to 2.00
SUSXM15J1TB ^{d)}	0.08 max.	3.00 to 5.00	2.00 max.	0.045 max.	0.030 max.	11.50 to 15.00	15.00 to 20.00	—	—

Table 3 (continued)

Unit: %

Symbol of grade	C	Si	Mn	P	S	Ni	Cr	Mo	Others ^{c)}
SUS821L1TB ^{a)}	0.030 max.	0.75 max.	2.00 to 4.00	0.040 max.	0.020 max.	1.50 to 2.50	20.50 to 21.50	0.60 max.	Cu: 0.05 to 1.50 N: 0.15 to 0.20
SUS323LTB ^{a)}	0.030 max.	1.00 max.	2.50 max.	0.040 max.	0.030 max.	3.00 to 5.50	21.50 to 24.50	0.05 to 0.60	Cu: 0.05 to 0.60 N: 0.05 to 0.20
SUS329J1TB ^{e)}	0.08 max.	1.00 max.	1.50 max.	0.040 max.	0.030 max.	3.00 to 6.00	23.00 to 28.00	1.00 to 3.00	—
SUS329J3LTB ^{a) f)}	0.030 max.	1.00 max.	1.50 max.	0.040 max.	0.030 max.	4.50 to 6.50	21.00 to 24.00	2.50 to 3.50	N: 0.08 to 0.20
SUS329J4LTB ^{a) f)}	0.030 max.	1.00 max.	1.50 max.	0.040 max.	0.030 max.	5.50 to 7.50	24.00 to 26.00	2.50 to 3.50	N: 0.08 to 0.30
SUS327L1TB ^{a)}	0.030 max.	0.80 max.	1.20 max.	0.035 max.	0.020 max.	6.00 to 8.00	24.00 to 26.00	3.00 to 5.00	Cu: 0.50 max. N: 0.24 to 0.32
SUS405TB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	11.50 to 14.50	— ^{b)}	Al: 0.10 to 0.30
SUS409TB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	10.50 to 11.75	— ^{b)}	Ti: 6 × C % to 0.75
SUS409LTB ^{a)}	0.030 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	10.50 to 11.75	— ^{b)}	Ti: 6 × C % to 0.75
SUS410TB	0.15 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	11.50 to 13.50	— ^{b)}	—
SUS410TiTB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	11.50 to 13.50	— ^{b)}	Ti: 6 × C % to 0.75
SUS430TB	0.12 max.	0.75 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 18.00	— ^{b)}	—
SUS430LXTB ^{a)}	0.030 max.	0.75 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 19.00	— ^{b)}	Ti or Nb: 0.10 to 1.00
SUS430J1LTB ^{a) g)}	0.025 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 20.00	— ^{b)}	N: 0.025 max. Ti, Nb, Zr, or combina- tion of these: 8 × (C % + N %) to 0.80 Cu: 0.30 to 0.80
SUS436LTB ^{a)}	0.025 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	16.00 to 19.00	0.75 to 1.25	N: 0.025 max. Ti, Nb, Zr, or combina- tion of these: 8 × (C % + N %) to 0.80
SUS444TB ^{a)}	0.025 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	17.00 to 20.00	1.75 to 2.50	N: 0.025 max. Ti, Nb, Zr, or combina- tion of these: 8 × (C % + N %) to 0.80
SUSXM8TB	0.08 max.	1.00 max.	1.00 max.	0.040 max.	0.030 max.	0.60 max.	17.00 to 19.00	— ^{b)}	Ti: 12 × C % to 1.10
SUSXM27TB ^{a) h)}	0.010 max.	0.40 max.	0.40 max.	0.030 max.	0.020 max.	0.50 max.	25.00 to 27.50	0.75 to 1.50	N: 0.015 max. Cu: 0.20 max. Cu + Ni: 0.50 max.

Table 3 (concluded)

Alloy elements not specified in this table and the element for which dashes (“—”) are entered in this table may be added as necessary.

- Notes
- a) When the product analysis is requested by the purchaser, the carbon content rate shall be as follows: SUS304LTB, SUS316LTB, SUS317LTB, SUS836LTB, SUS821L1TB, SUS323LTB, SUS329J3LTB, SUS329J4LTB, SUS327L1TB, SUS409LTB, SUS430LXTB: 0.035 % or under; SUS430J1LTB, SUS436LTB, SUS444TB: 0.030 % or under; SUS312LTB, SUS890LTB: 0.025 % or under; SUSXM27TB: 0.015 % or under.
 - b) Addition of Mo is permitted to a level where chemical composition of the grade concerned remains distinguishable, after the addition of Mo, from those of all other grades.
 - c) Addition of an alloy element is permitted to a level where chemical composition of the grade concerned remains distinguishable, after the addition of the alloy element, from those of all other grades.
 - d) If either Cu, Mo, Nb, Ti, N, or a combination of these elements is added as necessary, the content rate of the added element(s) shall be reported.
 - e) When either Cu, W, N, or a combination of these elements is added as necessary, the content rate of the added element(s) shall be reported.
 - f) When Cu and/or W is added as necessary, the content rate of the added element(s) shall be reported.
 - g) When V is added as necessary, the content rate shall be reported.
 - h) When either V, Ti, Nb, or a combination of these elements is added as necessary, the content rate of the added element(s) shall be reported.

6 Mechanical properties

6.1 Tensile strength, proof stress and elongation

Tubes shall be tested in accordance with **12.2.3**, and the tensile strength, proof stress and elongation shall be as given in Table 4. When the tensile test is carried out on Test piece No. 12 for the tube under 8 mm in wall thickness, the elongation shall be in accordance with Table 5.

Table 4 Tensile strength, proof stress and elongation

Symbol of grade	Tensile strength ^{a)}	Proof stress	Elongation %		
			Outside diameter		
			Under 10 mm	10 mm or over to and excl. 20 mm	20 mm or over
			Test piece No. 11	Test piece No. 11	Test piece No. 11 Test piece No. 12
			Tensile test direction		
		N/mm ²	N/mm ²	Parallel to tube axis	Parallel to tube axis
SUS304TB	520 min.	205 min.	27 min.	30 min.	35 min.
SUS304HTB					
SUS304LTB					
SUS309TB	520 min.	205 min.			
SUS309STB					
SUS310TB					
SUS310STB					
SUS312LTB	650 min.	300 min.			
SUS315J1TB	520 min.	205 min.			
SUS315J2TB					
SUS316TB					
SUS316HTB					
SUS316LTB	480 min.	175 min.			
SUS316TiTB	520 min.	205 min.			
SUS317TB					
SUS317LTB	480 min.	175 min.			
SUS321TB	520 min.	205 min.			
SUS321HTB					
SUS347TB					
SUS347HTB					
SUS836LTB					
SUS890LTB	490 min.	215 min.			
SUSXM15J1TB	520 min.	205 min.			
SUS821L1TB	600 min.	400 min.	12 min.	15 min.	20 min.
SUS323LTB					
SUS329J1TB	590 min.	390 min.	10 min.	13 min.	18 min.
SUS329J3LTB	620 min.	450 min.			
SUS329J4LTB					
SUS327L1TB	795 min.	550 min.	7 min.	10 min.	15 min.

Table 4 (concluded)

Symbol of grade	Tensile strength ^{a)}
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